THINGS WORTH MAKING

ARCHIBALD WILLIAMS

1773

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By

ARCHIBALD WILLIAMS

Author of "The Romance of Modern Invention," "How It is Made," "Victories of the Engineer," "Things to Make," "A Book of the Sea," etc., etc.

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PREFACE

THESE are days in which it is very well worth while to do for ourselves many things which, before the war, we were content to entrust to others. The " handy man " has come into his own; and the handy boy is probably appreciated as he never was yet. I therefore have got together a second book on " making things," being the more encouraged to do so by the welcome given to " Things to Make," written some six years earlier. In this task I have had the valuable help of Mr. Percy J. Wells, a first-class expert on woodwork, who contributes the very practical first eight chapters, containing instructions for fashioning a large number of useful articles whereon labour may be profitably employed. In Chapter XI. Mr. E. Lancaster Burne, a mechanical engineer, describes the building of a windmill for pumping and other purposes. This piece of mechanism should appeal to a good many of my readers who live in the country. Mr. V. E. Johnson, well known as a writer on mechanical and scientific subjects, is responsible for the chapters on A Model Gyroscopic Monorail Railway, Model Aeroplanes, and A Home-made Kaleidoscope. The last is a peculiarly fascinating apparatus. To Mr. J. C. S. Brough, editor of *The Woodworker and Art Craftsman*, I am indebted for the very useful chapter on Fretwork. The other fourteen chapters range over a number of subjects

which should prove of interest—sand yachts, model turbines, electric motors, electric railways, and so on. Any keen young amateur mechanic ought to be able to find in these 500 odd pages some things on which he will like to try his hand, even if he have not a well-equipped workshop, as a good many of the articles require the use of only the simplest tools. In selecting my subjects I have kept in mind the fact that we are not all interested in the same kind of construction, some preferring to work in wood and others in metal. I may conclude with the hope that any one who turns the book to practical account will consider its title to describe the contents fairly correctly.

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CONTENTS.

THINGS WORTH MAKING.

Chapter I.

JOINTS IN WOODWORK AND THEIR USES.

Nailed—Halved—Housed—Dovetailed—Mortise and Tenon—Mitre—Tongued—Dowelled—And Other Joints.

A CONSIDERABLE part of the book is devoted to woodwork, so no excuse is needed for referring to joints at some length in what may be regarded as a preliminary chapter, the careful study of which will repay the reader who has yet to learn how to do things in a shipshape manner.

The simplest forms of joints are not too difficult for an amateur to make, which is fortunate, as one cannot go very far in woodwork without using them.

Dovetail Nailing (Fig. 1, *a*).—This method is necessary only when the nails are driven into the end grain of the wood, as in fixing the sides of a box to the ends; the bottom of the box would be

attached by nails driven in perpendicularly. Fig. 1, *b*, explains the hold which a nail has when it enters the wood at right angles to the grain. The fibres are forced down, and in their attempt to regain their natural position they grip the nail. In the direction of the grain there is no such action, hence the necessity for "dovetailing" or sloping the nails. Fig. 1, *c*, depicts *skew nailing*, such as would be used in fixing the uprights in a frame for a shed or summer-house where there is not much strength required.

Housing (Fig. 1, *d*) is the name given to the joint when the whole thickness of one piece of wood is let into, or "grooved" into, another, as the diagram shows. Bookshelves and divisions are fixed in this way (Fig. 1, *e*). They may be nailed through the ends, but this should not be necessary if the shelf fit tightly into the groove, and there be a back to hold the whole thing rigid. Fig. 1, *f*, shows a variety of the same kind of joint known as "stopped housing," the groove not being cut right across—a method adopted in making hanging book-shelves and fixed shelves in cabinets, etc. Sometimes, however, a moulding is fixed on to the edge of the shelf (see Fig. 1, *g*), in which case the grooving need not be stopped, but can be taken right through, as the diagram shows, since the moulding will cover the joint. If the moulding be not carried round the end of the bookcase, it is usually shaped

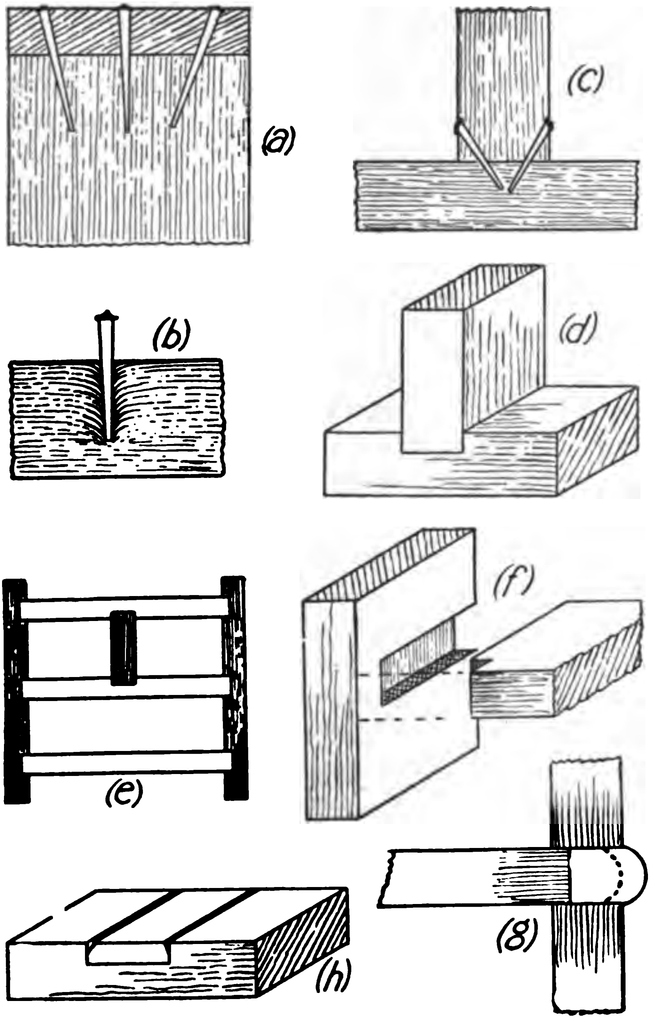

Fig. 1.—(*a*) Dovetail nailing; (*b*) nail forcing wood fibres apart; (*c*) skew nailing; (*d*, *e*) housing; (*f*) "stopped" housing; (*g*) moulding in front of housing; (*h*) starting a groove.

off at the end, as the dotted line shows. Where there are a number of shelves, this rounded edge takes off the squareness, and gives a little more depth to the look of the shelf.

The quickest way to cut the groove is to square the width across, then make a cut along the lines with a chisel corner, and another sloping cut on the inside (see Fig. 1, *h*). This will make a channel for the tenon or dovetail saw, which can then be used to cut down the depth. A chisel and mallet will soon remove the wood, care being taken that the bottom of the groove is quite flat and equal in depth from end to end. The right tool for cleaning out a groove is a "router," which can be bought at a tool shop ; but a good substitute is easily made by screwing two pieces of hard wood together, and fitting an ordinary firmer chisel into a slot cut in both pieces, as illustrated in Fig. 2, *a*. The slots should together be a little shallower than the thickness of the chisel, so that the screws shall pull the two pieces tightly together. This is always a very useful tool for clearing a groove or rebate to its right depth, and, of course, a chisel of any width can be fitted to it. If a smaller chisel be necessary, a hardwood wedge, well fitted at the edge, will hold it in its place.

Tongued Joints (Fig. 2, *b*) are used in angles of small work such as clock cases and boxes, the tongue being about one-third the thickness of the wood,

and the remainder worked away with the rebate plane. The groove is cut with a grooving plane or a plough. The angle can be strengthened by a glued block as shown.

Rebate Joints.—Fig. 2, *c*, shows a joint sometimes used for making boxes or trays. It can be nailed both ways, and is an improvement on that in Fig. 1, *a*, being stronger and not showing so much end grain, especially if the corner be rounded off. This joint is useful for making a drawer if the more difficult dovetailing cannot be managed. Fig. 2, *d*, shows the same type of joint for the back of a bookcase or cabinet. The best way to "rebate" is to gauge the width and thickness, and then fix a straight-edge (Fig. 2, *e*, A), which will act as a guide or "fence" for the plane B. Another way is to plane off the corner almost down to the lines, and then cut a channel for the plane to start in.

Halved and Lapped Joints.—These are very simple joints used in making frames, sheds, etc. Fig. 2, *f*, shows one "open," and Fig. 2, *g*, the same joint "closed," as applied to an "Oxford" frame. Half the thickness is cut out of the under side of the upright, and a similar half out of the top side of the cross-piece. The half depth must be carefully gauged from the front or "face side" on both edges, and the four pieces should be marked at one operation, as shown in Fig. 2, *h*. To ensure a close joint, the saw cut must be made inside the

lines and not on them, to allow for the thickness of the saw. The rebate for the glass or picture is cut out with a chisel, as the plane cannot be used in this case. Lap-halving is extremely useful in making a frame which has to be faced up with thin pieces of finely-figured and expensive woods. Fig. 2, *i*, shows a section of such a frame.

The "ground" or base is of pine or whitewood halved together, the joints in all cases being well glued and pressed together with a thumbscrew, the projecting ends being left on—a precaution necessary in all cases whether they are to be permanent or not, as they help to make a better joint and hold it whilst drying. When dry, the frame can be planed off flat and roughed or "toothed" with a toothing plane or the flat side of a rasp. This is done that the glue may hold much firmer than it would on a smooth surface. Then the thin piece of wood—rosewood, satinwood, Italian walnut, lacewood, figured oak, ebony, or any of the fancy woods which can be bought in ¼-in. thicknesses—is mitred and glued on with hand or thumb screws. The piece should project over the pine frame to form a rebate, as the diagram shows.

When quite dry, the edges will need planing and squaring and facing up with the thin wood in a similar way to the front. The front edges can project to form a round bead, and the result should be a very rich and tasteful frame.

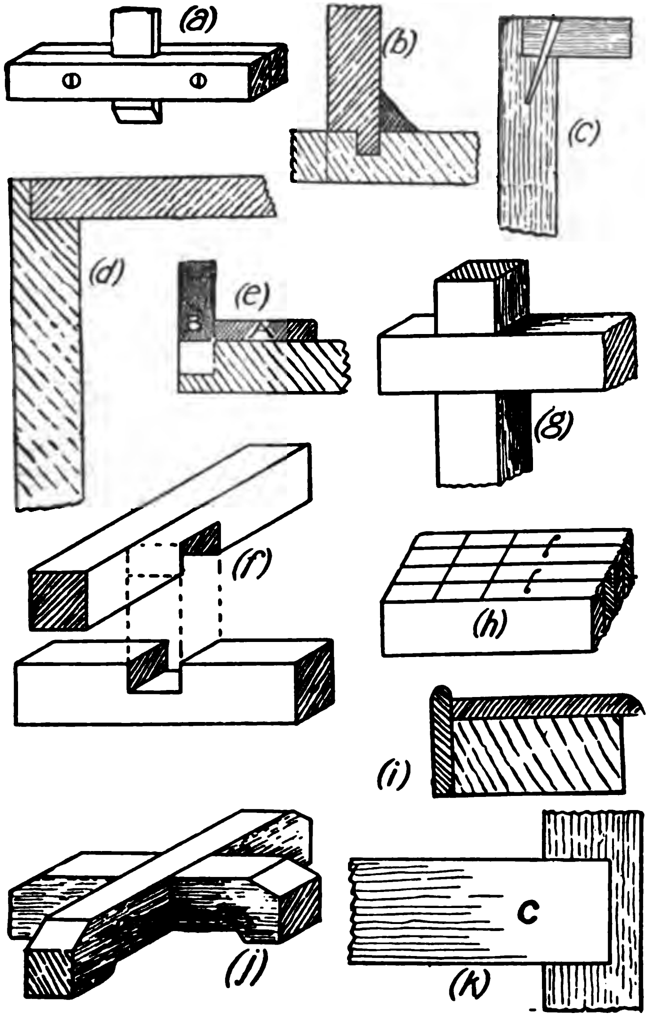

Fig. 2.—(*a*) "Old woman's tooth" for cleaning grooves; (*b*) tongued joint; (*c*, *d*, *e*) rebate joints; (*f*, *g*, *i*, *j*) "halved" joints; (*h*) marking-off for halved joint; (*k*) "stopped" halved joint.

The halving joint is also shown in Fig. 2, *j*, as it is used in a base for a flower or teapot stand or a music-stand. A stopped halving joint is shown in Fig. 2, *k*. This can be employed if it be undesirable to show the grain on the outside edge, as in a frame similar to the one described in Fig. 2, *i*, except that the edges would not be faced up. To cut this joint in neatly, the cross-piece, C, should be halved out first, and then laid on the other piece in the right place, and carefully marked round with a pointed marking awl or the corner of a chisel. The socket can be cut down inside the lines with a saw, and finished off with mallet and chisel. Although tight, well-fitting joints are necessary, the attempt to force a joint such as this too tightly into the socket will only end in disaster. The edges of C would be fractured and the fibres of the other piece forced downwards or bent. If care be taken in all these halving joints to just cut inside the line for the sockets, there should be no such result.

Mortise and Tenon Joints are used in the making of doors, tables, and various kinds of woodwork. They vary in shape according to the work they have to do. The mortise is the hole, and the tenon is the piece driven into it. In house doors these tenons go right through the uprights, or "stiles," of the door, and are wedged on the outside edge (Fig. 3, *a*). This "through" tenon is only necessary in large work, where extra strength is required.

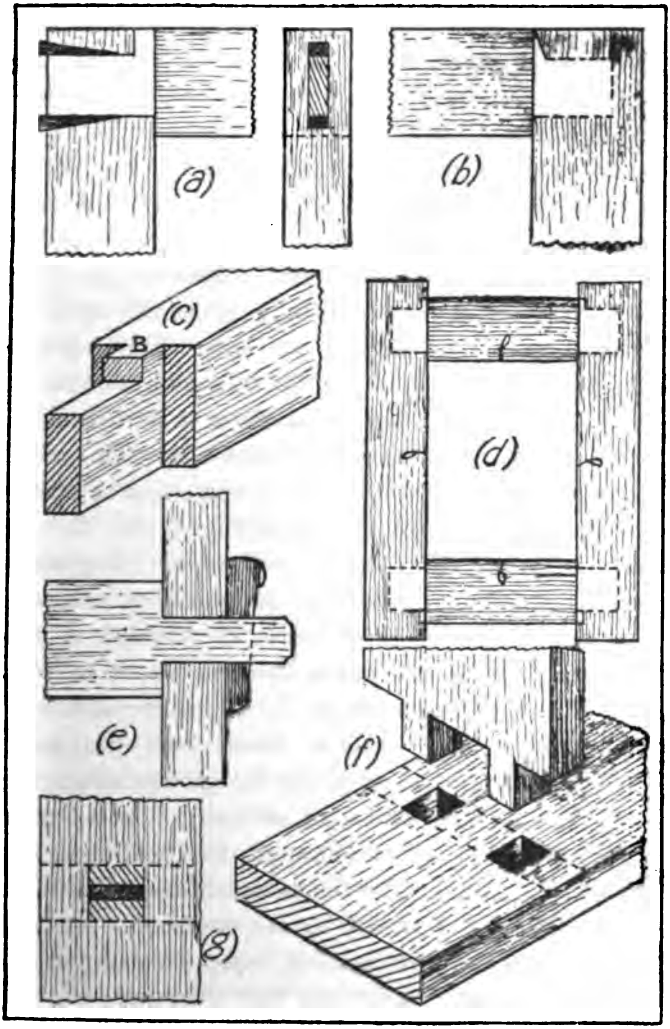

Fig. 3.—Mortise and tenon joints.

In smaller work, such as a cabinet door, the tenon is "stopped," and penetrates only about two-thirds of the stile. Fig. 3, *a*, shows the "through" tenon and the wedges (dark). The mortise is cut back at each end to take the wedge. The edge-on view of the stile shows the end of the tenon slightly shaded and the wedges darker. These wedges have to be driven in very carefully to avoid splitting a piece out of the end of the stile. They should be slightly bevelled off at the thin end, so that it clears the fibres of the wood when it is driven in. When cutting mortises in stiles near the ends, always leave a waste piece on for strength in working, as in the case of the frame (Fig. 3, *d*). In the next diagram (Fig. 3, *b*) is seen a "stopped" tenon, the joint generally adopted by cabinet-makers where any great strain or strength is not required; whilst the tenon itself is shown in Fig. 3, *c*, with a piece left on at B, which is called the "haunch." This haunch serves two purposes. It fills in the space made by the groove when the door is panelled, as in an ordinary house door; and it gives rigidity and strength to a rail, as in the frame of a table. The tenon and haunch is shown in Fig. 3, *b*, as it would be in a table, the haunch in this case being sloped. A tenon should occupy, laterally, about one-third the thickness of the wood. In cutting down the tenon be careful to keep the saw *outside* the lines.

Fig. 3, *d*, is an illustration of a door frame suitable for a cabinet or cupboard. It is made with a stopped tenon, and shows the haunch, which would only be used if the panel is to be grooved-in. A tenon will enter the mortise easier if the end corners be cut off, as a sharp square edge is likely to catch on the uneven sides of the mortise.

The next diagram (Fig. 3, *e*) shows a form of tenon which goes right through the wood and protrudes sufficiently to allow a wedge to be driven into a hole in the projecting part. This is a great advantage in such a thing as a standing bookshelf, as it allows for easy separation of parts if occasion requires. It is not glued, since the further in the wedge is driven the tighter does the joint become. But do not drive in the wedge too hard, or there may be damage done.

The *through tenon* shown in Fig. 3, *f*, is used when divisions in bookcases, cabinets, and show-cases, etc., are fixed into the tops and bottoms. In a division about a foot wide, three such tenons should be used. They go right through and are wedged as in Fig. 3, *g*. A saw cut is made down the centre of the tenon for about half its length, and the wedge is glued and driven into the cut. It should be noted that the wedge lies at right angles to the fibres of the other piece, for if it were parallel to them it would split the board from end to end.

Sometimes the cut for the wedge is made diagonally across the tenon, and if the tenon be large, two wedges may be necessary. Another precaution is, not to allow the wedge to penetrate the tenon so far as to split the division on the inside. However small the bookcase may be, this is the correct way to fix a division. If the tenons be cut out first and then laid on the exact places they

Fig. 4.—Cutting tenon.

should enter, and the mortises be prepared with equal care, a good joint will result.

Both sides of the board should be marked for the mortises, and the cutting out will be made easier if a hole be bored right through first; then cut halfway through with a chisel, and turn the board over to finish from the other side. *On no account* should the mortise be cut through from one side only, as there is a danger of breaking the wood away at the back. Neither should the tenons

fit too tightly across the width, for fear of splitting the board.

Mitre Joints.—The true mitre joint is made at an angle of 45°, as in picture-frames. In the first place, the mitre is sawn in a "mitre cut" (Fig. 7), and the "return" or corresponding mitre should follow the preceding one, as 1, 1, and 2, 2, in Fig. 8, *a*, to ensure a correct intersection.

Fig. 5.—Starting the cut for tenon.

It is a fatal mistake to cut the moulding into lengths first.

Then the mitre is shot with a plane, either in a "mitre shoot" or on a shooting board, and tested with a set mitre, for, if the angle be not a true one, the frame will not be square. It is quite possible to cut a true mitre at once with a fine saw. Frame-makers use a hand-machine for the joint, but an amateur is not likely to include this in his outfit. The makers also use a vice to hold the joints whilst

they are being nailed, but the worker at home must rely on simpler methods, such as the following:—

When the mitre has been tested and the joint is ready to fix, bore a hole with a bradawl through one piece; then hold the two pieces together with the joint accurately adjusted, and insert the awl again so that it enters the second piece (Fig. 8, *b*); glue the two mitres, and drive the nail right home, taking care that the second piece is held firmly either by hand or in the vice. The most important thing to remember when nailing a mitre is to bore the hole *at right angles* to the joint, which, of course, will also be at 45° to the outside edge, as in Fig. 8, *c*.

Fig. 6.—Cutting mortise Square used to ensure perpendicularity.

A much stronger and surer way of getting a good joint is to use a screw instead of a nail. This alternative method is well worth the extra trouble it entails of filling up the hole made by the screw head (Fig. 8, *d*). If the screw be at right angles to the mitre, there can be no doubt about the joint being a good one.

In small work, such as trays for workboxes or small frames, the mitre is generally "keyed" (Fig. 8, *e*). This means that a cut is made into the

mitre at the corner, and into the cut a thin piece of wood, usually veneer, is pressed and glued. This piece is known as the "key." The cut is oblique, and the key is put in with the fibres at right angles to the face of the mitre joint. It is obvious that this saw-cut can be made only when the mitre is closed; and the simplest way to effect this is to fit and glue up the frame, or tray, on a board in between blocks, which are temporarily fixed to it, as in Fig. 8, *f*. In the case of thin wood, inside blocks as well will be necessary. Of course the

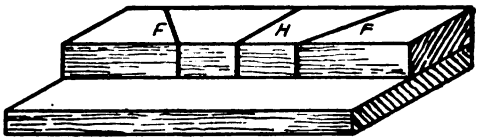

Fig. 7.—A mitre cut.

sides and ends must be of equal length, or the frame will not be square. When the mitres are dry the cuts can be made and the keys glued and inserted. They must be left to dry before being cleaned off flush with the frame.

Another way of keying mitres in thin work, such as a tray, is to build up the sides and ends of the tray on a square piece of wood with dimensions equal to the inside measurements of the tray-to-be. The pieces are held in position by pins or a little glue. If a piece of paper be put between the back pieces and the wood, and the three be glued to-

gether, they can be separated subsequently by inserting the blade of a thin knife between wood and wood. The slightest touch of glue is sufficient for the purpose.

CLAMPS AND CLAMPING.

To clamp means to hold fast, and in this case it is applied to holding fast a wide board or series of boards to prevent them warping and twisting, as in the case of a drawing-board, copper lid, ironing-board, or writing-flap. The simplest form of clamp, shown in Fig. 8, *g*, consists of a batten screwed across the width at right angles to the grain of the board. If slots be cut to take the screws they will allow the board to shrink or swell without splitting. These slots are holes or mortises about ½ in. long and as wide as the plain part of the screw is thick, the edges being bevelled off to take the screw head. In drawing-boards a hard-wood tongue is grooved into the ends—as the side-view shows—since it affords a better running surface for a T-square, but is not necessary except for such a special purpose. This ordinary form of clamp is strong, and may be used for any board if the projecting batten be not objected to.

Three other forms of clamping are illustrated in Fig. 8, *h*. A is the "tongue-and-groove," cut with a pair of "matching" planes, the tongue being worked on the board; B is a "loose tongue"

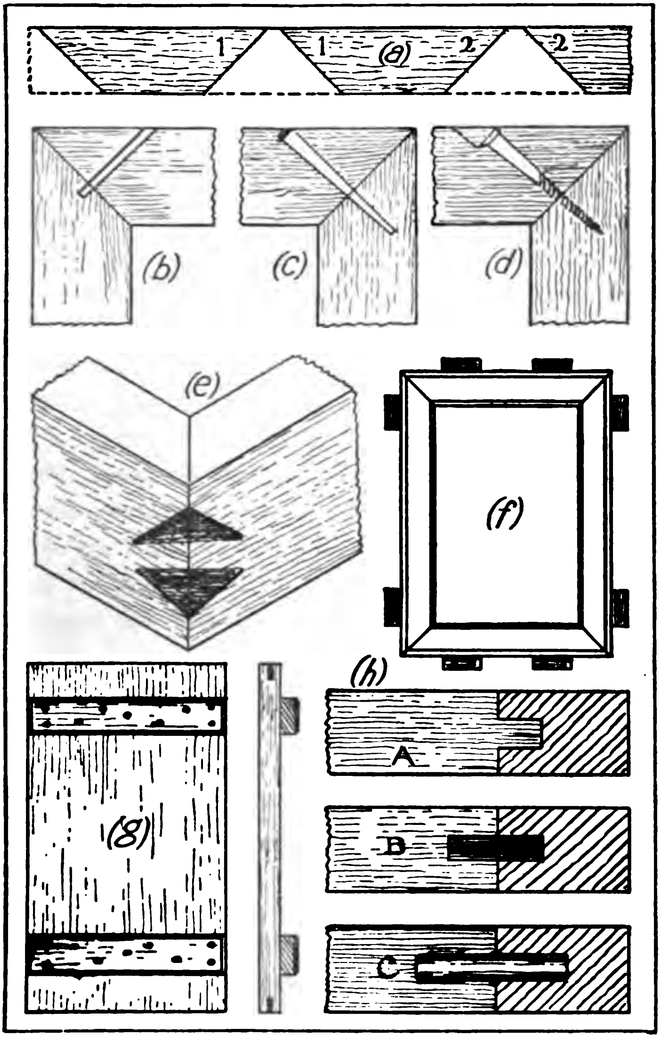

Fig. 8.—(a–f) Mitre joints; (g, h) clamping.

let into grooves in board and clamp ; and C is the "dowelled clamp"—quite the easiest for an amateur—round pegs being used to hold the parts together. All three can be used for drawing-boards, and for writing or wall flaps.

The next variety (Fig. 9, *a*) is known as the dovetail or keyed clamp. It is sunk into the board about one-third of its depth, and dovetailed on the edges and along its length, although the lengthwise taper is not essential except in so far as it ensures a good fit being made by driving in the clamp. This is the best clamp for a copper lid, in which nails or screws should not be used. Fig. 9, *b*, shows how the handle for the lid can be fixed with its ends cut into the clamp, and wooden dowels driven on the skew right through to the under side of the lid. Dowels through the clamps will give them additional strength.

Dowels are often used in the place of tenons, and, though not as strong, the joints effected with them are simpler and quicker in the making. The dowels are usually of birch or beech, and can be bought ready for use in 3-ft. lengths of ½ in., ⅜ in., or ¼ in. diameter. Oil-shops sell them as curtain-rods and flower-sticks at 1d. and 2d. a length. Short boring "bits"—known as "twist" or "dowel" bits—can be purchased to fit any of the three sizes. Great care must be taken to bore the holes upright, and also to mark their positions

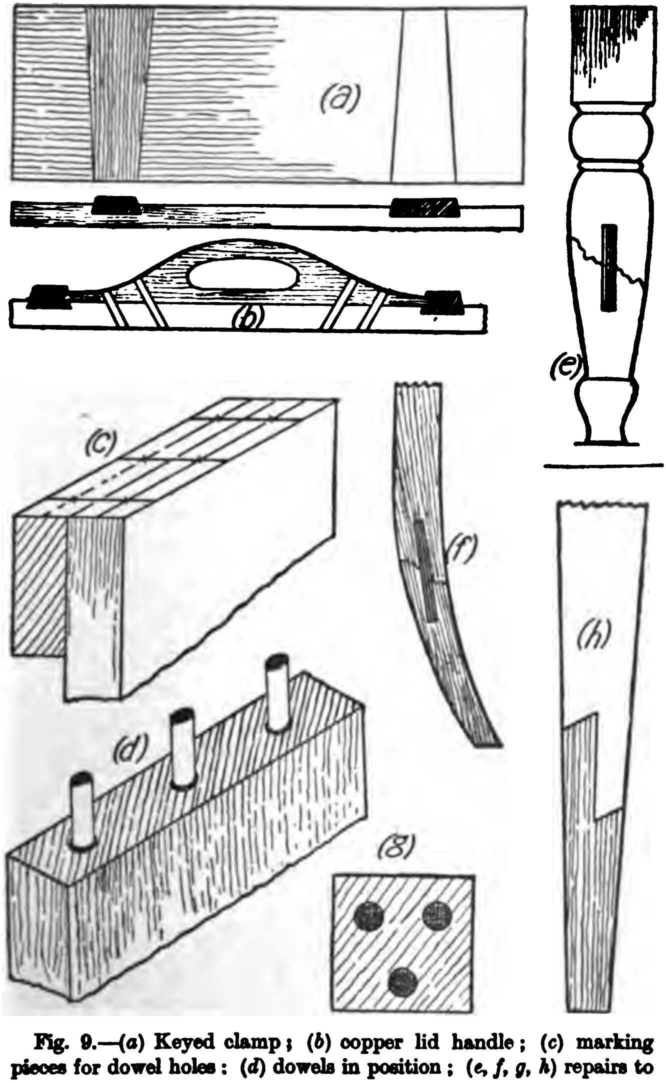

Fig. 9.—(*a*) Keyed clamp; (*b*) copper lid handle; (*c*) marking pieces for dowel holes: (*d*) dowels in position; (*e, f, g, h*) repairs to furniture.

correctly on both pieces of wood. Fig. 9, *c*, shows the clamp and the board with gauge lines down the middle and squared lines to intersect them at the points where the boring will start. Gauging must be done from the " face " side of both pieces. The depth of the holes will vary according to the work, but 1¼ in. will be about right. As a rule, the holes are countersunk round the top to provide a small channel to hold any surplus glue which may be scraped off the dowel as it enters. A little glue should be dropped in the hole and the dowel driven in. As these dowels fit tightly, ***the air is compressed behind them and will split the wood unless one or two lines be drawn down the dowel with a marking gauge to give the air an outlet.*** Care must be taken to cut the dowels off a little shorter than the depth of the hole in the clamp. If the top ends be slightly filed off, as shown (Fig. 9, *d*), they will enter the hole more easily. When everything is quite ready for gluing, the holes, dowels, and joints should be well covered with glue, as the end grain of the wood will absorb most of it.

All these clamp joints must be held in the " cramp " until they are dry.

Dowels are also used to strengthen joints in table and other tops, but their chief use is in chair-work. They are particularly handy in repairing a broken leg or back. In Fig. 9, *e* and *f* show the " repair " in two kinds of legs. To mark the spot for boring,

drive in a thin French nail about halfway, then pinch or file off the head and file the top of the stump to a good point. Knock the other broken part into its place very carefully, and pull the leg apart again, withdraw the nail, and the holes it has made in both parts give the points for boring. When the dowel is ready, the fracture should be well glued and cramped up to dry, or, if no cramp be available, a fracture may hold by itself, and all superfluous glue can be washed off with a rag and warm water.

The right position for dowels in a square leg is shown in Fig. 9, *g*.

Splicing.—Fig. 9, *h*, illustrates a stronger joint than dowelling, which necessitates the introduction of a new piece of wood and repolishing.

Dovetailing.—This joint is used in all kinds of woodwork and in various forms. Fig. 10, *a*, illustrates a common "through" dovetail and its socket. The angle for cutting is about 1 in 6 or 8, and the size of the dovetail varies according to the work. Sometimes a dovetail is halved and stopped when used on a stretcher for a frame, bench, or seat, and the joint will appear as in Fig. 10, *b*. To mark off dovetails, a gauge must be set to the thickness of the wood and lines run across the sides of each end. A bevel should be used to mark the angles, but the proportions of the dovetails must be carefully measured out on the wood

first. A good distribution in a joint two inches wide would be to divide it into four, taking two middle parts for the "tail" and the outside quarters for the "pins" (Fig. 10, *a*), which apportions the strength equally; but in the finer joints of a drawer the proportion is 5 or 6 for tails to 1 for the pins. In making the joint it is usual to cut down the line of the dovetail first, then to hold the piece firmly on the end of the other, insert the tip of the saw into the cut (Fig. 10, *c*), and press down and draw it out; this will leave a line on the end of the under piece similar to the shape of the dovetail. When the socket is sawn, the cut must be made inside the line to ensure a tight fit. The waste side pieces of the tail are sawn away and the socket cut out with mallet and chisel.

Drawer Dovetailing.—The front and back of a drawer are shown in Fig. 10, *e*. It will be noted that the "pins" are made very fine, as this method has proved to be strong enough for the work. The back of a drawer is always shallower than the front, a space being left at the top to allow a free passage of air when the drawer is pushed in, and at the bottom to admit the drawer bottom, which is grooved into the front and screwed up into the lower edge of the back.

There are several ways of fixing-in a drawer bottom. The section (Fig. 10, *f*) shows a bottom sliding in a groove ploughed into the side of the

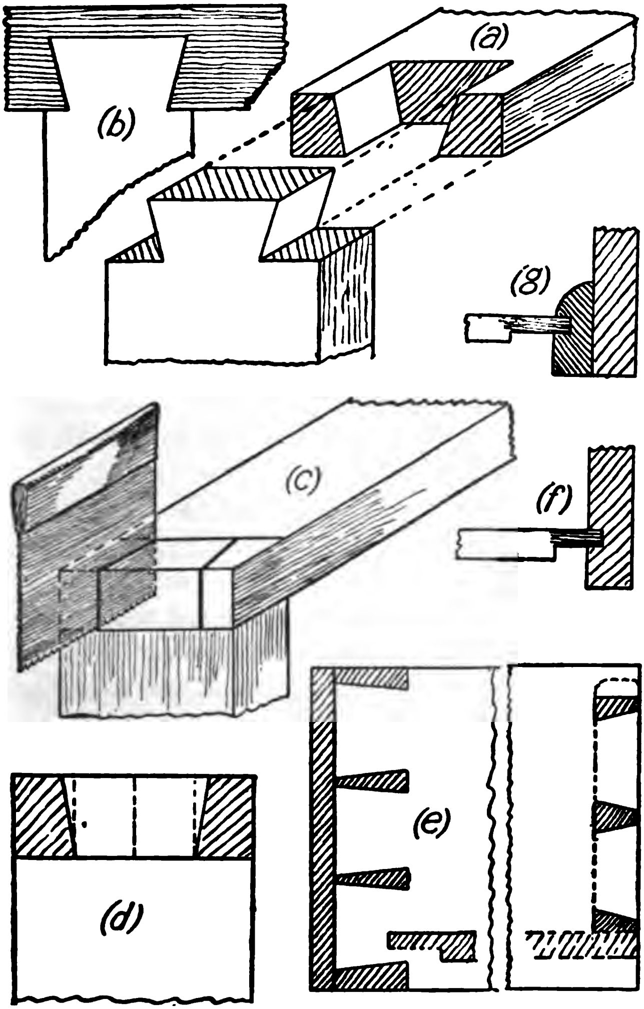

Fig. 10.—(*a–e*) Dovetailing; (*f*, *g*) grooves for drawer bottom.

drawer, the edge of the bottom being rebated down to fit it. Unless the drawer side be at least half an inch thick, this groove weakens it; and to overcome this, and also to give a wider surface for running, a piece called a "slip" (grooved and rounded on the top) is glued on the inside of the drawer side. This is shown in the sectional diagram, Fig. 10, *g*. These are the two common methods. There are others suitable for special work only. In a strong, roughly-made drawer—say for a work-bench—the bottom parts are merely nailed together, and a slip is nailed to the side for it to rest and run upon.

Long and Short Shoulder Joint.—This is the joint used in making doors for cupboards and cabinets, mirror-frames, etc., when the panel or glass is put in from the back. It is a mortise and tenon joint, so rebated that one shoulder is longer than the other. Fig. 11, *a*, shows the top of the assembled frame, and Fig. 11, *b*, is a view of the tenon and shoulders. The uprights of a door or frame are called "stiles," and the horizontal pieces "rails." A section of the stile is shown in Fig. 11, *c*, with a panel beaded in; and Fig. 11, *d*, gives a similar section showing a glass, silvered, blocked in, and protected by a thin back, screwed on behind. The blocks are wedge-shaped to fix the glass, and are usually glued or pinned in. In house doors and backs of cabinets which are framed up, the

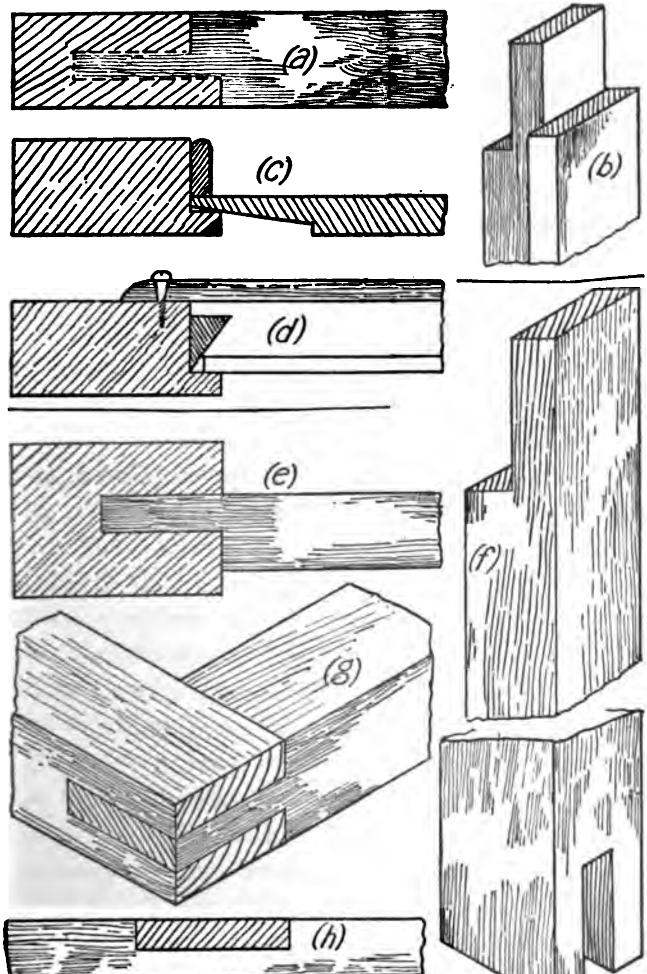

Fig. 11.—(*a*, *b*) Long and short shoulder joint ; (*c*) fixing panel in frame ; (*d*) fixing mirror and back ; (*e*, *f*) " barefaced " tenon ; (*g*) angle bridle ; (*h*, *i*) common bridle.

panels are fixed in a groove; but when the panel or glass may have to be removed, it is usual to fix them, as previously described.

The type of tenon shown in Fig. 11, *e* and *f*, is known by the name of "barefaced," having only one shoulder. It is used in work where the rail is much thinner than the mortise piece, and is often applied to kitchen tables and such things. An "open" mortise and tenon joint is given in Fig. 11, *g*. It is known as the "angle bridle," as *h* and *i*, Fig. 11, are the form of common "bridle." Fig. 11, *h*, shows the joint as it appears closed, and Fig. 11, *i*, the forked part separately.

Chapter II.

THINGS FOR THE HOUSE.

Window Seats—Lamp and Corner Brackets—Wall Mirrors—A Table Mirror—A Hall Flap—A Stationery Case and Bookshelf.

WINDOW SEATS.

A BOARD of whitewood, 16 in. or 18 in. wide, fitted into a bay window and supported by pieces of the same width at the ends and middle, makes a strong window seat—and a comfortable one if cushions be added. The boards may be ordered ready planed and fit for immediate use, and should be $\frac{7}{8}$ in. thick when finished.

If the bay have angles larger than right angles, the measurements are taken from the floor line, allowance being made for the skirting. It is not necessary to give directions for getting the shape of the board correct, as the reader's common sense will show how it should be done. Fourteen inches, exclusive of cushion, is a convenient height for such a seat, which will be more comfortable if it slope an inch or so towards the back.

The legs, or supports, should be tenoned through

the seat, two tenons, each 2 in. wide, being sufficient. The end supports stand in 3 in. from, and are parallel to, the ends of the seat. A centre support is essential, or the duty may be distributed among two supports, duly spaced; and a back rail, 3 in. wide (B in the plan), will add to the rigidity of the seat, which, however, would be quite strong enough without it. Fig. 12, *a*, is a front elevation, and Fig. 12, *b*, an end view, showing the seat with a back added. This last, if thought desirable, is screwed on through the seat, its parts resting against the window-ledge. The front edge of the seat should be rounded and the floor end of the supports cut out as shown.

If the bay be square-cornered, the same type of construction can be followed. The seat has at each end an arm-shaped end, as represented in Fig. 12, *e*. The seat can be tenoned right through the ends (Fig. 12, *d*), or nailed on to a fillet, as in Fig. 12, *e* and *f*; and the back—of matched boarding—is fixed to the back edge of the seat or on to a fillet, as in the end view (Fig. 12, *e*). In a similar way a corner settle can be made, or a seat to stand at right angles to the fireplace, the back boards (if arranged horizontally) being screwed to the ends of the seat.

LAMP BRACKETS.

The type of bracket illustrated in Fig. 13, *a*, is known as a "lamp" or "candle" bracket because

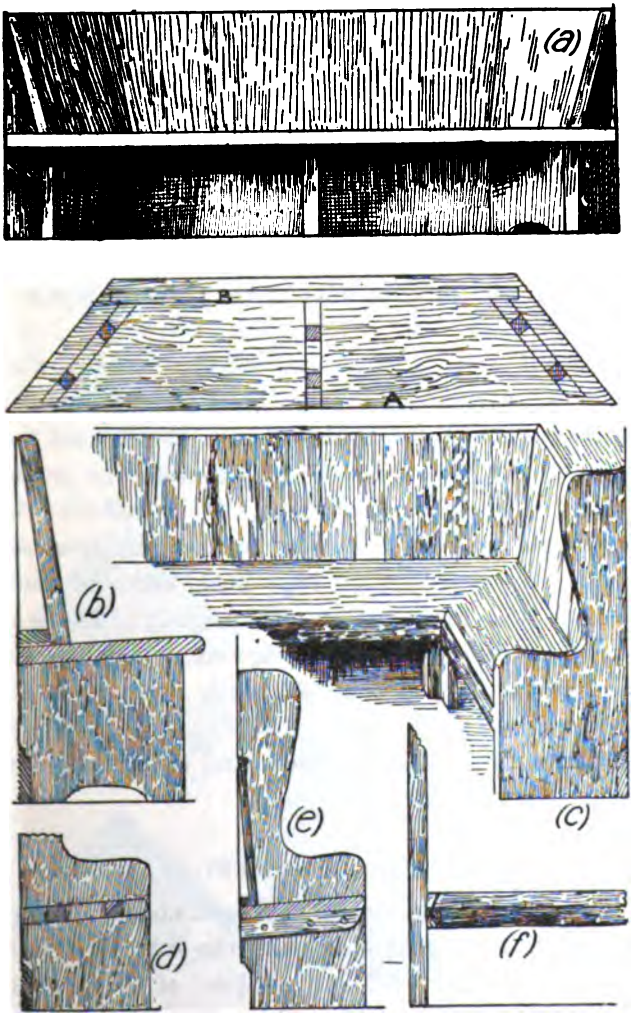

Fig. 12.—Window seats.

of its high back, which is intended to protect the wall from the heat and flame; but it is obviously suited to all purposes to which a bracket can be put. It lends itself to a variety of shapes, the one shown suggesting the base of a lamp or candlestick. The back is 14″ × 5″, the circle 8 in. in diameter, and the bracket support about 5″ × 2″. The wood, whether hard or soft, should be ⅝ in. thick when finished.

Fig. 13, *a*, is a front view of the bracket, and Fig. 13, *b*, a side elevation showing the bracket tenoned through the back. Screws would hold the bracket, but, owing to the direction of the grain, not so strongly as the tenon. It is sufficient to screw the shelf to the back and to the bracket. Brass screws, with their tops flush with the shelf surface, will not look at all unsightly. There is plenty of room for a little carving or inlaying in the back of such a bracket, which is smart whatever wood be used.

Alternative shapes for back and shelf are given in Fig. 13, *c* and *d*.

A CORNER BRACKET.

This is even simpler than the last, and, of course, can be of any convenient size, the bracket shown being about 18″ × 6″, and of ¾-in. or ½-in. wood (Fig. 13, *e*). The shelves should preferably be "stop-housed" (see Fig. 13, *f*), though good secure

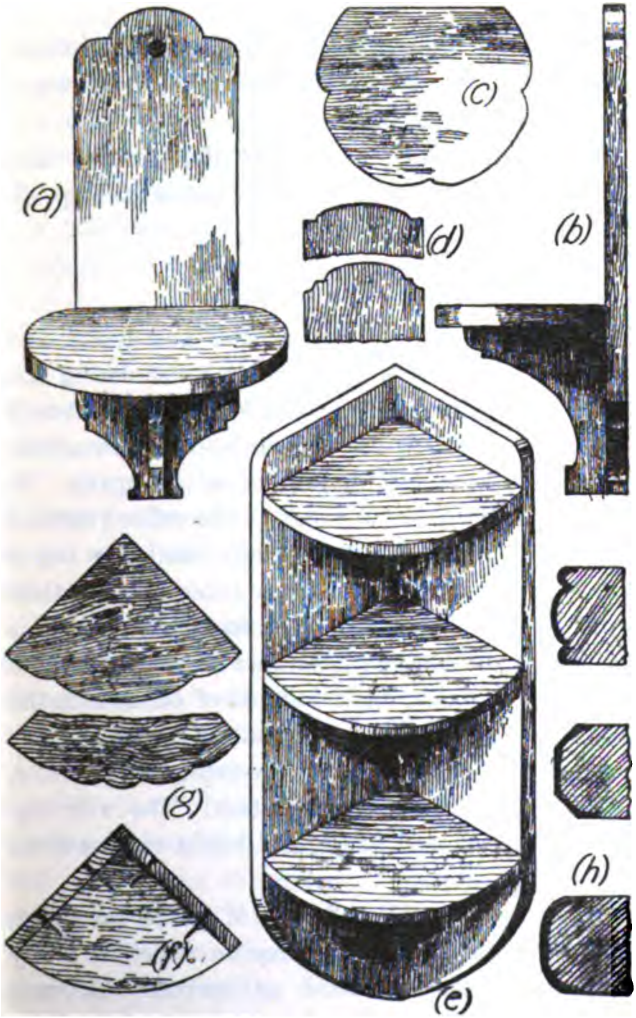

Fig. 13.—Lamp and corner brackets.

screwing from behind (Fig. 13, *f*) ought to make a firm job. The two back pieces can be screwed together, or, better still, rebated.

Alternative plan shapes for the shelves and mouldings on the front edges are given in Fig. 13, *g* and *h*, respectively.

WALL MIRRORS.

Any one who can cut a mortise and tenon and work a rebate should be equal to constructing the frames shown in Fig. 14, *a* and *b*. The first should be made of whitewood, and stained or enamelled, or it would look well in walnut or mahogany. It is 30 in. high and 17 in. wide. The stiles (vertical pieces) and bottom rail are 2 in., and the top 6 in., wide. A and B show the stiles thicker than the rails, and slightly rounded on the front. This adds smartness to the frame, and is easily obtained by setting the rails back, instead of flush with the stiles. It also provides a shallow break to the small moulding or square on the top (see Fig. 14, *a*, B) and the bead along the bottom. The wide top rail forms a recessed panel, and might receive some simple decoration.

The next frame (Fig. 14, *b*) is of similar construction. The outside shaping may be varied in many ways, and the fan inlaid or carved. Silvered plate-glass can be obtained at any glazier's, bevelled-edge sheets being the most expensive. Full

information on fixing the glass and back will be found in the chapter on "Joints" (pp. 32, 34). The usual way of hanging a wall mirror is to screw "glass-plates" on the back. These, costing about 4d. a pair, have a projecting piece in which there is a hole to engage a nail driven into the wall, or a screw, if there be wood to take it.

A TABLE MIRROR.

The ordinary toilet mirror, pivoted at the centre of the side, is a very troublesome thing to put right when, as often happens, the centre screw wears out. It must be tied down or propped up, and if these temporary supports be removed, it usually turns right over, presenting its wooden back to the user.

One or two simple devices dispose of the screw altogether; but, before they are described, something may be said about the glass frame itself. The making of so useful an article gives an opportunity of employing some specially fine or well-figured wood. In the chapter on "Joints," in the section dealing with "halving," there is a description of a frame of pine or whitewood halved together and then "faced" with thin wood. This wood—say ¼ in. thick—can be obtained through any fretwood agent. Rosewood, lacewood, silky oak, maple, satinwood, or Italian walnut are all choice and suitable woods for this particular pur-

pose. They can be mitred at the corners, or butted and glued on to the pine frame underneath. Graywood (stained sycamore), with a rosewood bead on the edge, will make a dainty combination of colour, which can be advantageously applied to wall or other types of mirrors or even picture-frames.

In this instance we must suppose such a frame to be made, or a solid frame such as is specified for the two wall mirrors already treated. Then comes the question of making a stand for it, or adopting some device for fixing it in position. The simplest method is shown later in Fig. 18, *a*. A piece of wood, A, about 1½ in. wide and ½ in. thick, is screwed to the back of the frame, and another piece of the same width and thickness is fixed to it—about two-thirds the way up—by a thumbscrew which can be loosened to allow the strut to be moved out or in to give the required angle. A hole for the thumbscrew is bored through the strut; a screw socket is let into, or screwed on to, the farther side of A. If variation of the slope of the glass is unimportant, the strut may be permanently screwed to A.

Another device, in which the thumbscrew does not appear, is shown in Fig. 14, *d*. Two slips, C C, of ⅜-in. wood, 1½ in. wide, are hinged on to the back of the frame as struts. These are held together by a cross-piece, D, attached to them by brass screws. Two other pieces, E E, hinged on to

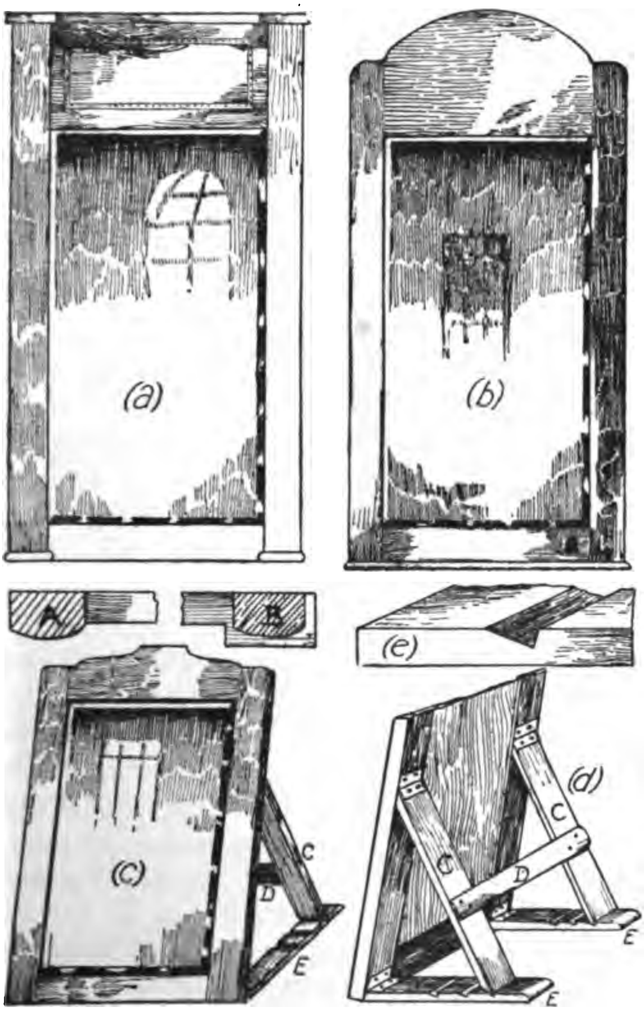

Fig. 14.—(*a*, *b*) Wall mirrors; (*c*, *d*, *e*) table mirrors.

the bottom of the frame, are notched on the upper side so that the bevelled lower ends of the struts shall engage with the notches and support the mirror-frame at any angle desired.

Neither of these simple devices takes up more room than the ordinary base of a centre-swing mirror, or entails more than an hour's work.

A HALL FLAP.

A shelf or "flap" which can be let down is particularly convenient in a hall or near a dining-room door, where a permanent shelf might be a serious obstruction to traffic. Fig. 15, *a*, is a sketch of the flap with the shelf up, and Fig. 15, *b*, a front elevation with the shelf down, the dotted line showing the shape of the bracket when it is turned back, either to right or left.

A handy shelf would be 20 in. to 24 in. long, and 12 in. to 15 in. wide; one bracket, 8 in. to 10 in. high, will be sufficient support. If the flap be longer it will require two brackets, but this should not increase the difficulty of construction. It can all be made of $\frac{3}{4}$-in. wood. The back is one piece, with the grain horizontal. The flap should preferably be "clamped" at the ends, or it may be kept flat by strips, $1'' \times \frac{3}{4}''$, screwed on underneath at each end, either flush with the end or $\frac{1}{2}$ in. from it. The clamp, however, looks neater, and is more effective in keeping the flap straight and flat.

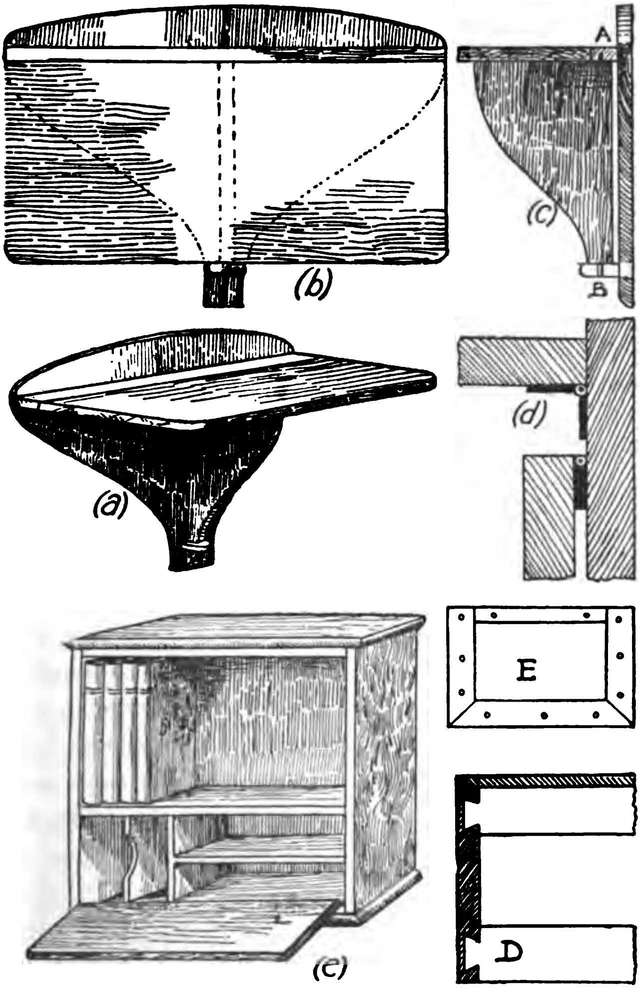

Fig. 15.—(*a–d*) Hall flap ; (*e*) stationery case and bookshelf.

There must be a hinging-piece (A in Fig. 15, *c*), 1 in. wide, and of the same thickness as the flap which is hinged to it. This piece, screwed on through the back, provides the necessary recess for the bracket when the flap is down. The bracket itself can be fixed in two ways: either (1) by simply hinging it on to the back with two ordinary butt hinges—this is not the strongest way—or (2) by inserting a dowel-pin top and bottom to engage with holes bored in the hinging-piece, A, and in a small piece tenoned or screwed through the back at B. In this case the back edge of the bracket must be rounded off to allow it to revolve.

If the bracket be pinned it will swing back on either side, whereas hinges allow it to move in one direction only. Fig. 15, *d*, shows how the hinges —2-in. brass butts—are fixed to the bracket and back when centre-pins are not used. The back piece may be left square or shaped like the bracket; the corners of the flap should be rounded off, so as not to catch on things. Two brackets for a longer flap can be fixed in exactly the same way, but must be hinged or pinned near the ends, and swing inwards without overlapping.

A STATIONERY CASE AND BOOKSHELF.

This kind of case is extremely handy for standing on a table (Fig. 15, *e*). If made large enough, the flap serves as a writing-table, but the article shown

here is meant to serve only as a table-case for stationery and books.

The case is 16 in. high, 12 in. wide, and $7\frac{1}{2}$ in. deep over all, and made of $\frac{3}{4}$-in. wood, except the divisions for the pigeon-holes, which would be of $\frac{1}{4}$-in. stuff, while the flap and back are of $\frac{1}{2}$-in. This case is, in effect, a box with an extra top and bottom added, and a shelf which is " housed " in grooves in the sides. The bottom must be dovetailed up into the ends, and two rails are dovetailed into them at the top as shown in D, the back one standing in as far from the edge as the back is thick. It is not necessary to have a solid inner top, as the finished top will cover these rails, which gives less work. The pigeon-hole divisions are grooved into the bottom and under side of the shelf. The flap may either be clamped at its end or have a ledge screwed on the inside near each end. The hinge should be cut right into the bottom edge of the flap, and screwed on to the bottom of the case. A lock or brass turn-button serves as fastening. The top is attached by screws put through the two rails before the back is fixed in. The last fits into a rebate. The base moulding, about $1\frac{1}{2}'' \times \frac{3}{4}''$, is mitred and screwed to the bottom as shown at E.

Chapter III.

MORE THINGS FOR THE HOUSE.

Fireplace Screens—A Flat Fire-screen—A Draught-screen—A Pair of House-steps—A Box for Firewood—A Trunk-stand—A Dinner-wagon—An Overmantel—A Music-stool—Umbrella Stands—A Reading-stand—Book-stands.

FIREPLACE SCREENS.

THE most effective and useful form of fireplace screen is seen in Fig. 16, *a*. It is usually about 2 ft. 6 in. high, the centre 2 ft., and the wings 9 in., wide. The framework is made out of 1¼-in. square wood of any kind, hard or soft, either halved (Fig. 16, *a*, A and B) or tenoned together. The wings are hinged with ordinary brass butt hinges. Silk or tapestry can be tacked round inside or on the back, or laced over the top and bottom rails. As an alternative, the frames might be grooved and filled in with well-figured 3-ply panels.

A FLAT FIRE-SCREEN.

This screen (Fig. 16, *a*) is a standing frame, made to take a piece of silk embroidery tacked on behind.

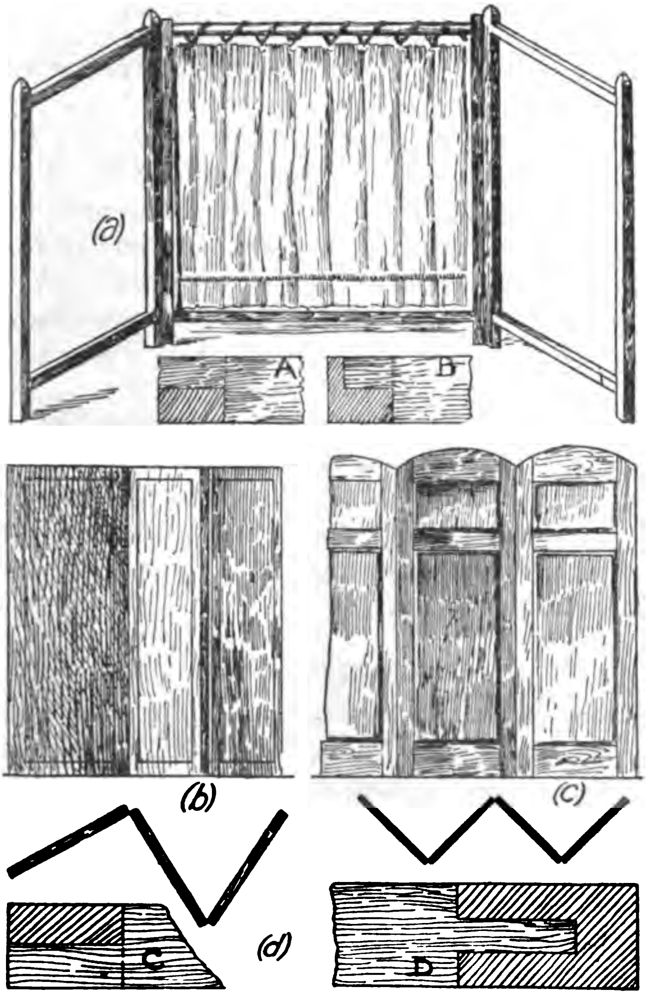

Fig. 16.—(*a*) Folding screen for fireplace ; (*b, c, d*) folding draught-screens.

It is 2 ft. wide and 2 ft. 8 in. high, therefore large enough to cover almost any grate.

The uprights and rails are 1½ in. wide and 1 in. thick, and the rails are stop-mortised (Fig. 16, *b*) into the uprights. As a simple decoration, the edges of the rails are worked into a series of short curved bevels with a chisel, and finished with a file. The top ends of the uprights may be shaped as shown. Some kind of foot, as at Fig. 16, *b*, is necessary to support the screen.

The foot is slotted into the upright like a bridle joint. Diagram A (Fig. 17) shows a plan of the slotting. The obliquely shaded parts are the upright. B is a foot, slotted to take the upright, shown separately at C. The parts are assembled with glue.

A DRAUGHT-SCREEN.

This screen will be found useful for other purposes than a mere "draught-stopper." It can be made in three or four folds, which are generally 18 in. or 20 in. wide and from 4 ft. to 5 ft. high. Simple screens are constructed with 2-in. battens halved or tenoned (Fig. 16, *d*, C and D) together, the frame so formed being covered with canvas or linen and then hinged on opposite edges with butt hinges. Better articles are panelled, the best 3-ply panels being ideal for the purpose. Fig. 16, *b*, shows one of this type made of walnut. The

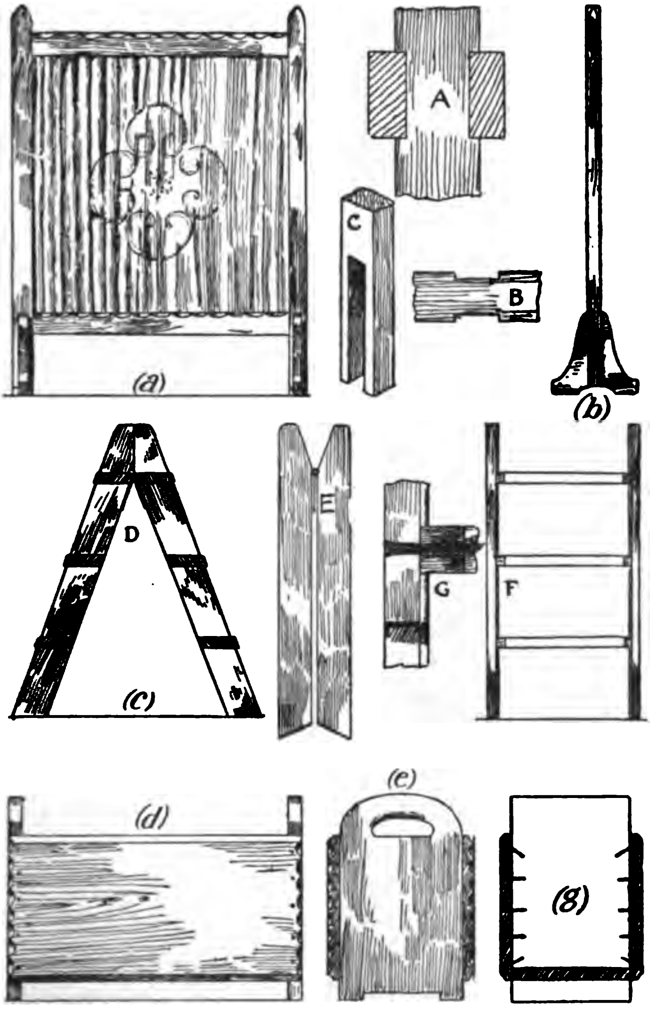

Fig. 17.—(*a*, *b*) Flat screen for fireplace; (*c*) folding steps; (*d*, *e*, *g*) box for firewood.

uprights or stiles are $1\frac{1}{2}'' \times 1''$, and the top and bottom rails $3'' \times 1''$.

A PAIR OF HOUSE-STEPS.

Fig. 17, *c*, shows a pair of folding house-steps with two sets of three treads. The height of the steps, open, is 2 ft.; width at the base, 2 ft. 2 in.; the width of the side pieces, $2\frac{3}{4}$ in.; and of the treads, 3 in., to allow for a slight projection beyond the front edge of the sides. The thickness of the wood is 1 in., finishing $\frac{7}{8}$ in.

In D the steps are shown open; in E closed. F is a front view, and G shows the tread grooved into the side and nailed. As a rule, a bead is worked on the step side of the front edge of the sides, and serves to give the depth of the step grooves, about $\frac{3}{16}$ in.

To set out the treads and centre-line, lay two side-pieces on the ground, as in D, and arrange them so that they are 21 in. across at the base. The centre-line above the hinge can then be marked, and the pieces cut accordingly. The second pair are cut by the first.

The sides should be laid flat again with the bevelled ends together, and the position of the treads should be marked out with a bevel parallel to a line struck across the lower ends.

The bead on the front edges of the sides is not essential, but if it is omitted a gauge-line must

be run along both edges to give the depth of the groove. The treads, 11½ in. long, are skew-nailed to the sides, and their projecting corners cut off down to the sides. Join the two halves with a pair of 3-in. strap hinges (Fig. 17, E), and the job is finished.

A BOX FOR FIREWOOD.

This, a strong box made to hold short logs of wood, is designed to stand in a recess, and is not too large to be carried comfortably. Length, 2 ft.; width, 12 in.; depth inside, 12 in.

The ends (Fig. 17, *e*) are 17 in. high, to allow for a handle-hole at the top. The parts are nailed together, ends to bottom and sides to both. Fig. 17, *g*, shows the dovetail nailing that should be used. A number of hollows are gouged out from the vertical edges of the sides by way of ornamentation. Black the box with a little lampblack mixed with button polish, and applied with a camel's-hair brush.

A TRUNK-STAND.

A trunk is packed and unpacked most conveniently if raised above the floor to about chair height. A good strong stand for the purpose is shown in Fig. 18, *b* and *c*. Its length is 2 ft. 6 in. on the top; width, 18 in.; and height, 16 in. The legs are 2 in. square; all the other parts are of 1-in. wood. Any of the hard woods—oak, walnut,

or mahogany—is suitable, but oak is by far the best. The long and short rails are $3\frac{1}{2}$ in. wide, and are tenoned with a haunch (Fig. 3, *b*) into the middle of the legs, as seen in the right-hand side of Fig. 18, *c*.

The ends should be glued up first. When they are in the clamp, a straight-edge must be laid across the legs to show whether they are quite flat. If the surfaces of the legs are not parallel to the straight-edge, there is something wrong with the cramping, and the cramp must be moved either up or down at one end until it forces the legs into their correct position. When the side rails are glued the same test must be applied, and in both cases the legs must be square to the rails.

The left-hand side of the plan shows the top pieces 3 in. wide, mitred and screwed down to the frame. The edges of these pieces are planed off to a half-round—which is finished with glass-paper—and project over the legs about three-quarters of an inch. To stiffen the stand and support the trunk, two cross-rails, B and C, are let into the top to rest on the edge of the rails underneath, to which they could be securely screwed. If there be any projections at the mitres and ends of B and C, plane them down so that the whole top is flat and true to a straight-edge test.

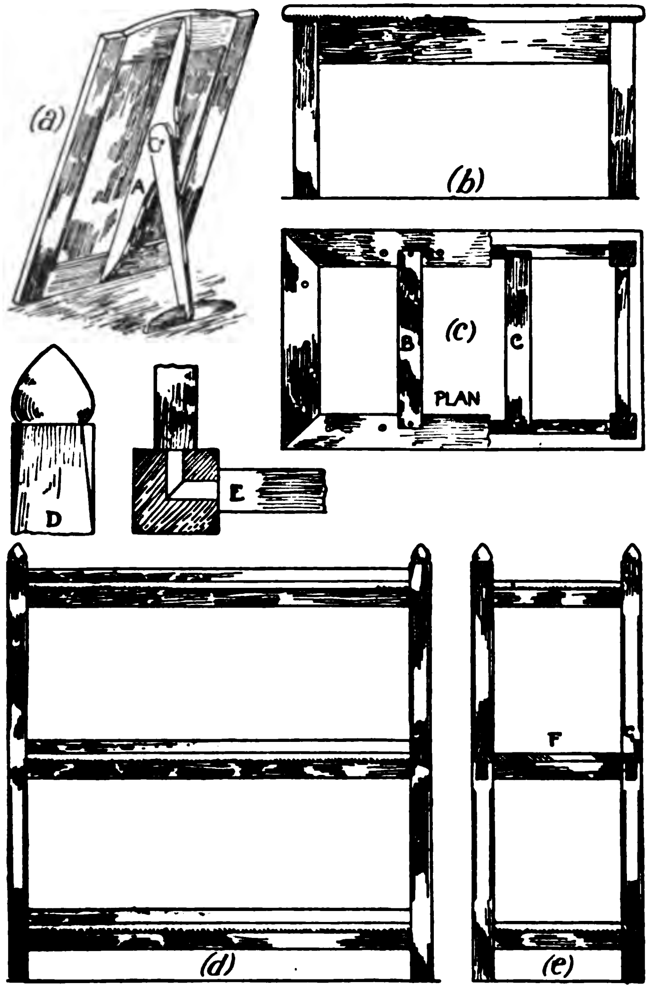

Fig. 18.—(*a*) Table-mirror; (*b*, *c*) trunk-stand; (*d*, *e*) dinner-wagon.

A DINNER-WAGON.

A dinner-wagon—a tier of shelves supported by four corner-posts—is, next to a sideboard, the most useful piece of furniture in a dining-room. A convenient size is 3 ft. long, 3 ft. high to the top of the post, and 14 in. wide on the shelf. Such a wagon is shown in Fig. 18, *d* and *e*, front and end views respectively.

The posts are 1½ in. square; the rails supporting the shelves, 1¼″ × 1″; the shelves, of ½-in. wood.

To mark out the positions of the mortises, the four legs should be laid close together on the bench and the distances be marked across them with pencil and square. The marks must be repeated on the adjoining side. The lower edge of the lowest rail is 3 in. from the bottom, and the top edge of the top rail 4 in. from the top end of the leg. The middle rail is halfway between the other two, or somewhat nearer to the top than the bottom.

In the larger detail, E, the tenons are shown meeting each other, and mitred to have the longest possible length. When the mortises and tenons have been cut and the rails fitted, the "chamfer" or bevel on the edges of the legs should be worked. It is usual to mark the depth of the bevel on each side with a pencil. In this case the depth is ¼ in. The edge is cut off with a chisel, the grain of the wood being carefully watched to avoid tearing it

up where the fibres happen to be a little twisty. The wide surface of the bevel should be finished flat with an iron spokeshave or a scraper. The ends of the bevel, called the "stops," are cut on the slope, as the drawing shows.

The finial, or shaped top of a post, must also be formed, before any gluing up is done, with a chisel and finished with a file. A large detail of it is drawn at D. This sketch also shows the corners of the leg cut off to a bevel, tapering away to nothing at the top of the shelf.

When all the bevels and finials have been worked, the ends should be glued and cramped. The legs and rails must be tested with square and straight-edge, as described in making the trunk-stand. Whilst the end dries, the shelves are prepared and cut out to fit into the legs. This very important part of the work must be done with care and accuracy. The length of the shelf between the front legs must be equal to the distance between the shoulders of the rail underneath the shelf. To get this, lay the rail on the shelf and make a mark from each shoulder. Then, with a square, run lines across on the back edge of the shelf. To get the end distance on the shelf it is best to lay the legs and rails—forming the end—up to the shelf and use them as a gauge. This must be repeated at the other end of the shelf.

In sawing the corners out of the shelf, make the

saw cuts inside the lines. The two other shelves may be cut to length from the first. Test each shoulder on a shelf with the shoulder on the rail which supports it. This is necessary to ensure good joints. The edges of the shelves are rounded on the front and ends only. A section is given at F in Fig. 18, *e*, showing the shelf on the rails. At the back is a piece, G, screwed to the back of each shelf to prevent things falling off behind. This piece is 1½ in. wide and ⅜ in. thick, and to allow for it the shelf is ⅜ in. narrower than full width by this amount. Before the final gluing up is done, two holes should be bored in each end rail and three in each front and back rail for the screws which hold shelves to rails. No. 6 screws, 1¾ in. long, will be quite large enough.

When the front and back rails are glued in, the shelves should be laid in place and cramped up with them. Finally, the shelves are screwed down and the back slips screwed on, the top edge of the slip being rounded like the edges of the shelves.

Some dinner-wagons are fixed on casters, but this is hardly necessary in one made for ordinary home use.

AN OVERMANTEL.

The ordinary overmantel, with its plate-glass and tiers of shelves supported on ornamental turned spindles, is rapidly going out of fashion, but many

people like a shelf above the fireplace on which to display their china and other treasures.

A simple form of overmantel is shown in Fig. 19. It is 4 ft. long and 2 ft. 3 in. high. The back is framed up into panels, which could be of

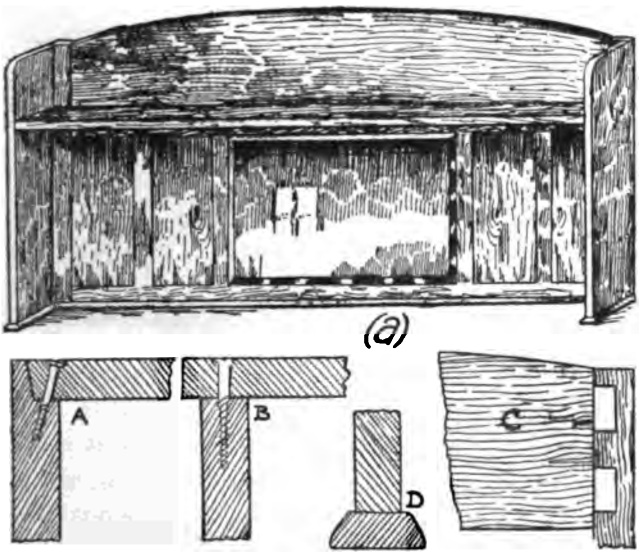

Fig. 19.—An overmantel.

wood or filled with pictures. The shelf is 6 in. wide, housed into the ends, which are rebated to take the back, or screwed on as in A and B. Brackets, if used, are also housed up into the shelf, and screwed through the back. If the height of the shelf be 21 in., it will leave room for a wide

rail as a background to set off a clock or vase. The tenons for the wide rail are seen at C, and a small moulding for the base at D. This last can be screwed up from underneath. If a mirror be desired, one may be fixed in the centre panel, as described in the chapter on "Joints" (Fig. 11, *d*). The

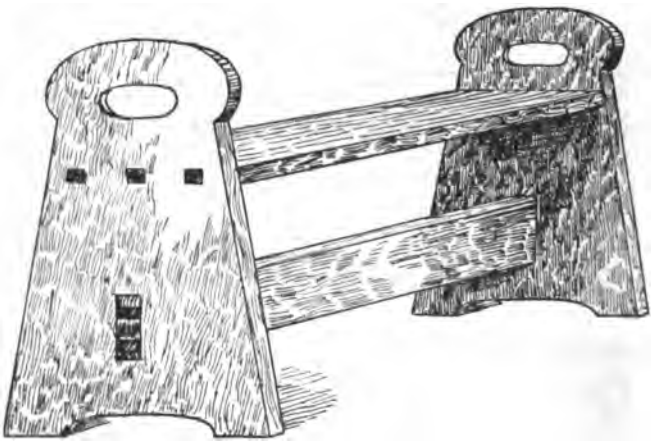

Fig. 20.—Music-stool.

overmantel is attached to the wall with "glass-plates."

A MUSIC-STOOL.

The stool illustrated by Fig. 20 can be made of hard or soft wood, but oak is perhaps the best for the design shown. Wood of, say, 1 in. thickness might be ordered to size and shape and sent ready for making up. The seat and rail are both tenoned right through and wedged. It is usual to strap a

cushion on to such a seat, which, when not in use, can be pushed under the piano out of the way. A seat for one person should be about 2 ft. long, 19 in. or 20 in. high, and 11 in. wide; while a duet seat should be 18 in. longer, and made in the same way. The ends might well be embellished by a little carving or simple inlay work.

UMBRELLA-STANDS.

A strong, useful stand is shown in Fig. 21, *a*. It is made throughout of 1½ in. square oak, mahogany, or walnut, or any other suitable wood; is 2 ft. 6 in. long, 2 ft. 6 in. high, and 9 in. wide, and is put together with mortise and tenon. Square legs or round (bought) may be used. The zinc pan to catch the drip must be of such a size as to fit snugly over the lower rails. An enlarged-scale shape for the top of the posts—made with chisel and file—is shown at A.

The next stand, of simpler make (Fig. 21, *b*), is intended to fit into a corner. Two ¾-in. boards, 2 ft. 8 in. high and about 11 in. wide, are screwed together to form a right angle. Two other pieces, F, 4 in. wide, are screwed close to their front edges. Two more pieces, the shape of which is seen at B in the plan, are fitted in between the two front uprights and screwed into them from behind. Nothing else is required except two ½-in. slips fixed to the back boards at the bottom to

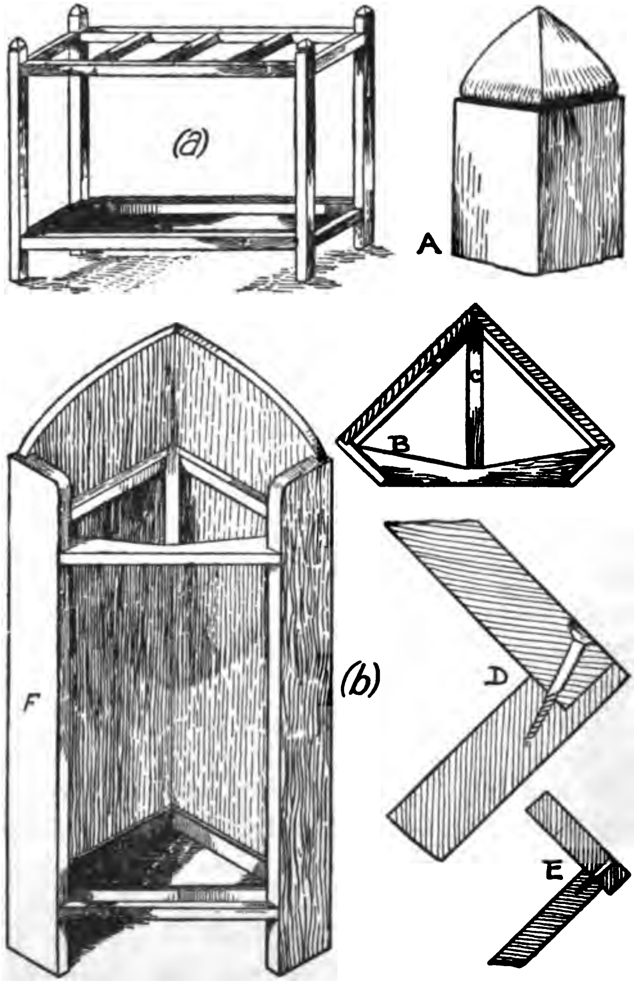

Fig. 21.—Umbrella-stands.

support the zinc tray, and perhaps a rail, C, tenoned into the front piece and screwed through the back to divide the stand into two parts. D and E are diagrams to show two methods of screwing the sides to the uprights. Rebating, as at D, is the better way ; but screwing on, as at E, is the quicker. The edge of the side-piece projects slightly. It is well to remember that the height of the rails in an umbrella-stand should not be above the top of the ribs, for if they be there is always a danger of catching and breaking the umbrella.

A READING-STAND.

A stand which will hold books in such a position that they can be read comfortably by a person sitting in a chair or propped up in bed, will find a use in most houses.

The following description and accompanying diagrams (Fig. 22) deal with a stand made out of ordinary gaspipe, obtainable at any ironmonger's. Its cost is but a fraction of that of an equally strong stand bought ready-made.

For the stand proper one requires the following items of piping, known technically as " $\frac{3}{4}$-in. gas " (that is, $\frac{3}{4}$ in. diameter inside and 1 in. outside), with fittings to match it :—

One piece, with socket at one end, for upright, A. The length of this will be decided by the height of the chair or bed with which the stand will be used.

One piece, E, 11 in. long, threaded at one end, without socket.

Two pieces, 24 in. long, for legs, B B, of stand, which are flat on the floor; threaded at one end, and with sockets.

Two "springs," C C without sockets.

One "bend," D, with one socket, to unite A and E.

One tee, F, to unite C C, and A.

To begin at the floor and work upwards. Screw C C into F, and B B into C C. As these joints are to be permanent, and must be as rigid as possible, clean the threads thoroughly with petrol or benzine to remove any grease, and *wet* them before screwing the parts together. This will make the joints rust up and become practically solid. If a little sal ammoniac be dissolved in the water, rusting will be more rapid.

Make sure that the tee is vertical when the legs lie flat on the floor.

Next screw the upright A into F. The joint in this case must permit movement, so the threads should be oiled. To the top of A screw D (oiled joint), and to D screw E (rust joint). The freedom of the joints at the ends of A is to allow E to be moved to and fro without shifting the feet.

The desk itself may be made of any wood, but oak or mahogany, finished and polished as well as the maker can manage, will give most satisfaction.

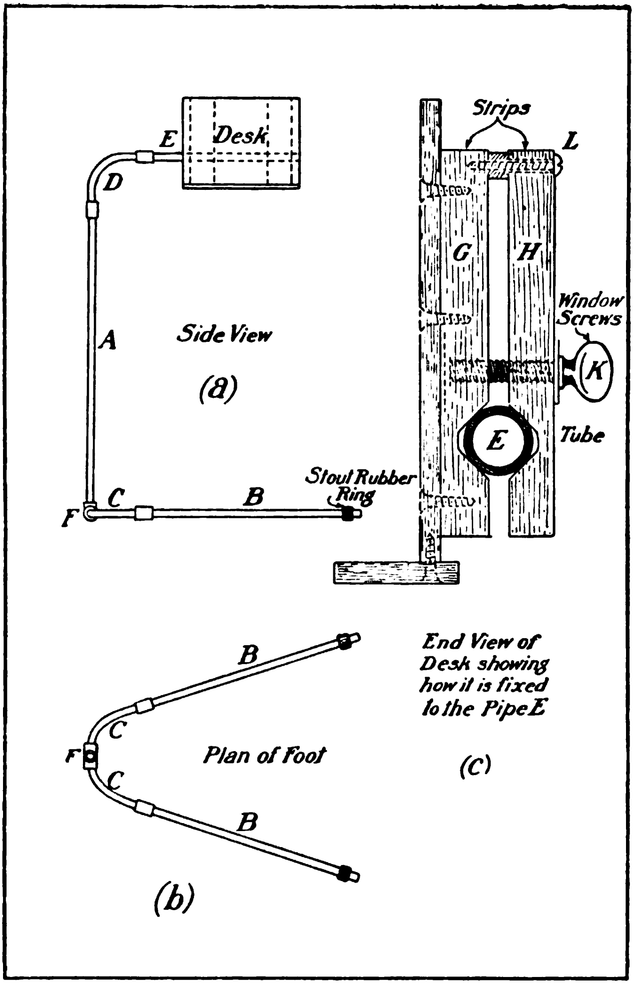

Fig. 22.—Details of gas-pipe reading-stand.

The back is stiffened by two cross-pieces, G G, notched as shown in Fig. 22, *c*.

Two other pieces, H H, similarly notched, are held up to the tube F by window screws, K K, and by loose screws, L L, which prevent them from getting out of line.

As the upright has to bear most of the strain, it might be of "water" instead of "gas" quality. The bore in the first case is smaller, but the outside diameter is the same, so that the same fittings will do for both kinds. The cost of the stouter piping is rather higher.

The joints where the "springs" screw into the tee may be strengthened at a small extra expense. Get the ironmonger to increase the length of the thread a little at the tee end of the springs, and to supply two "backnuts" to fit. These backnuts are run on to the springs before the last are screwed into the tee, and when the springs are in position are screwed up as tightly as possible against the tee. The backnuts should be damped, so as to be incorporated in the rust joints.

When not in use the stand may be dismembered by unscrewing the upright from the foot and the desk bar.

For appearance and cleanliness' sake the iron parts of the stand should be given a couple of coats of good oil or enamel paint.

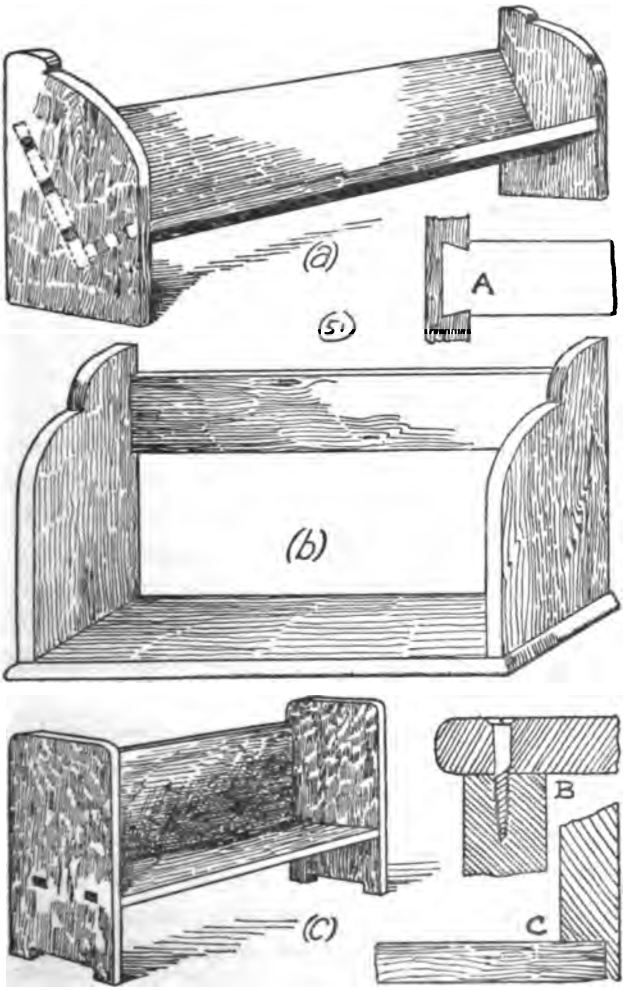

Fig. 23.—Book-stands.

BOOK-STANDS.

"Rests" or "stands" for books are very useful on a writing-table to hold any reference or other books. They may be of any size, construction, and design, and made with the simplest joints. Useful dimensions—12 in. or 14 in. long, 8 in. high, 6 in. wide. The length can be extended to 24 in. if need be. Any good hard or soft wood, but preferably hard, like oak, can be used. Fig. 23, *a*, shows a stand with a trough arrangement for the shelf, which should be at right angles to the back-piece. Both shelf and back are mortised through the ends and wedged. The shape of the ends is a matter of personal taste. The stand shown in Fig. 23, *b*, is of shelf form. The bottom is screwed up into the ends; the edges, which project just the thickness of the wood, are bevelled or rounded off. The $1\frac{1}{2}'' \times \frac{1}{2}''$ rail at the back should be dove-tailed in as seen at A; or made wider, and re-bated and screwed as at C; or, simpler still, a back can be screwed on as at B, the end edges being rounded off.

A third type (Fig. 23, *c*) has the shelf tenoned through, and the back fixed either as at A, B, or C. A large rest may have a handle-hole cut in each end.

Chapter IV.

CUPBOARDS.

Curtain Wardrobes—Kitchen Cupboards—Medicine Cupboards—A Music and Magazine Cupboard.

CURTAIN WARDROBES.

MANY bedrooms are too small to take a wardrobe in addition to the other, and necessary, furniture ; yet some such convenience is needed in most bedrooms. As a rule, a cupboard fills in one recess, but generally gives insufficient accommodation, so resource is had to pegs on the back of the door. This, however, has disadvantages. The clothes are exposed to all the dust, and look untidy, and the door is slowly but surely weighted down till it catches on the carpet and gives trouble. Why not, then, fill in another recess, or corner of a room, with a curtain wardrobe ?

Taking the recess first, its average length is 3 ft. 6 in. and its depth 14 in. A sketch is given (Fig. 24, *d*) showing the curtain half drawn, and the other parts, few in number. The top of the

wardrobe should be 6 ft. from the floor. At that height two battens, A, 12 in. long, 2 in. wide, and ⅞ in. thick, are nailed to the wall at the ends of the recess. Then the top board, B, is nailed down on to the battens. A piece 2½ in. wide is also nailed on the front edge of the top at C. At the bottom

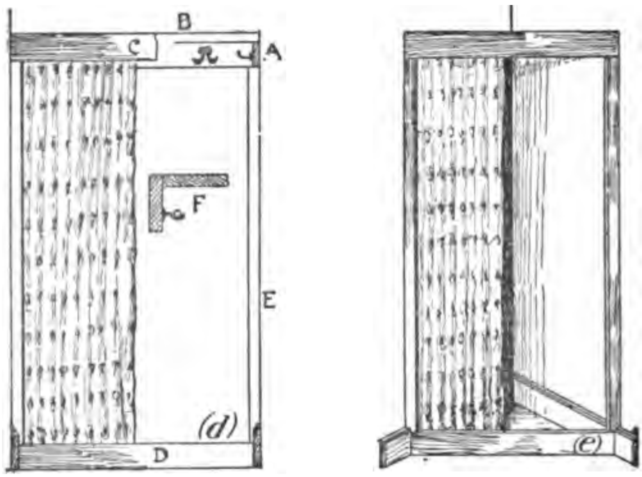

Fig. 24.—Curtain wardrobes.

a board, D, 2 in. wide, is fitted in between the skirting and skew-nailed to it, to keep the floor dust out. When the curtain is drawn towards the wall, the bottom of it will touch the skirting and not quite reach the wall. To fill up the space left, a strip of wood, E, a little thicker than the skirting, is nailed to the wall between C and the skirting

board. The curtain falls behind it and makes the closing in more complete.

One of the ½-in. round wooden sticks sold by oilmen makes a good curtain-rod. Diagram F shows the rod on a brass "cup hook" screwed into the front piece. Dress and cloak hooks can either be screwed up into the top or fixed to a batten nailed to the wall. To be quite secure from dust, the joints between the top board and the wall should be pasted over with brown paper.

The corner wardrobe (Fig. 24, *e*) is not quite so spacious as the other, but gives a little more work. The top is fixed in the same way as described for Fig. 24, *d*; but the width of the boarding is increased to about 20 in., which may mean using two or more boards. In this case it is best to make the top of "matched" boarding for the sake of the tongue in the joint. The front and floor pieces, and strips on the wall, are fixed as already described, and the curtain rod and hooks are screwed up in a similar way. The woodwork should be painted on the front.

KITCHEN CUPBOARDS.

These can be made entirely of match boarding, and quickly, as the boards are ready for use. Fig. 25, *a*, is a front elevation of a corner cupboard, 5 ft. high and 2 ft. long on each side of the back. The two uprights are 5 in. wide, or the width of

the boards used, which may be 4 in., 5 in., or 6 in.

The top and bottom of the cupboard should be prepared first. The boards for the top are nailed to a batten or fillet fixed $\frac{3}{4}$ in. in from the edges of the two sides. The bottom boards are nailed to a batten fixed flush with the edges. Fig. 25, *b*, shows the shape of the top and bottom corners as cut after nailing to the battens. When that has been done, the upright boards of the sides are nailed on to the fillet and down through the top board. The diagram at A shows them in position at the top.

All the boards used will fit into one another with groove and tongue, except the two uprights, from which the tongue is removed to make a flat joint for the doors. These uprights are nailed securely at top and bottom.

The doors are made as in diagram B, with two ledges and a brace. They are hung with iron cross-garnet hinges, screwed to the front. Put bolts on the left-hand door, and a good cupboard-turn on the right.

To finish off the top of the cupboard, a piece of the boarding is shaped to the front line and screwed on the top, projecting about one inch beyond it. A piece about two inches wide should also be nailed under the front edge of the bottom board. Shelves can be fixed where desired, shaped as shown in

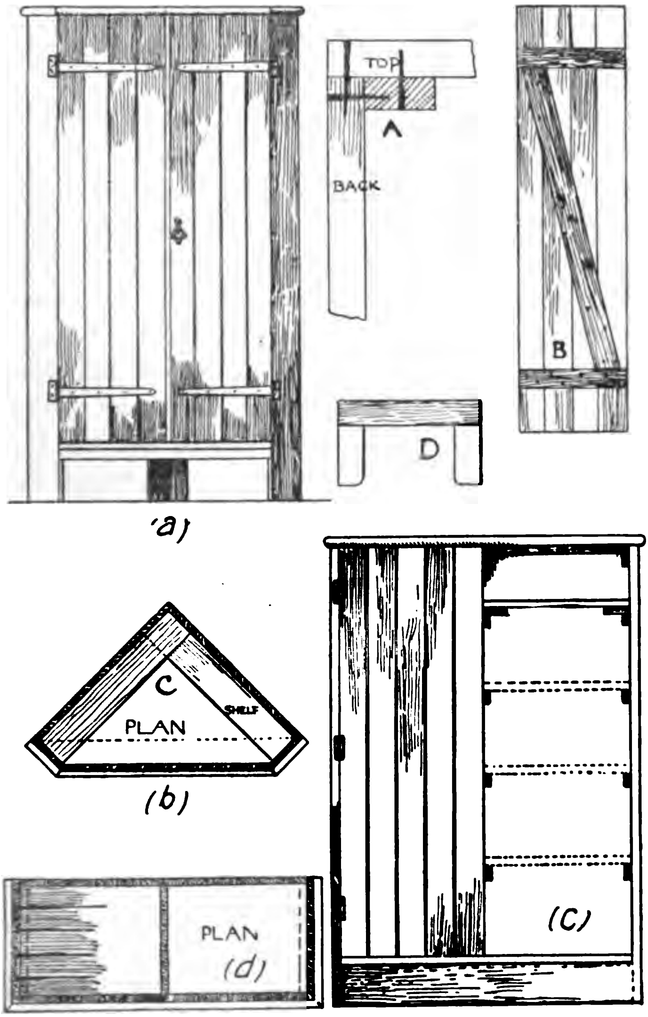

Fig. 25.—(*a*, *b*) Corner cupboard for kitchen ; (*c*, *d*) cup board in recess.

Fig. 25, *b*, the back piece lying on the others for support.

The second cupboard (Fig. 25, *c* and *d*) is suitable for standing in a recess or against a wall. It is 4 ft. 6 in. high, 3 ft. 2 in. wide, and 15 in. deep. In this case the battens for shelves are nailed to the sides, and the top and bottom nailed down to them and through the end boards. The back boards are fixed in an upright position.

The doors are made as for the corner cupboard, but are hung on "H" hinges. The space under the bottom is filled in with a board, and the top is finished off like that of the other cupboard. A partition might be fixed in the centre.

MEDICINE CUPBOARDS.

These necessary articles generally combine bookshelf and cupboard. They hang on the wall or stand on the mantelpiece. As a rule, they are of whitewood or pine, and left the natural colour of the wood. Some people, however, prefer to paint or stain them. More expensive specimens are made in hard woods and polished.

A simple cupboard with a shelf is shown in Fig. 26, *a*. It is made of ½-in. whitewood throughout, except the back, which is a ¼-in. board. Length, 24 in.; depth, 7 in.; height of ends, 18 in.; height of cupboard, 9 in. The bottom and shelf are nailed to the ends; but before they are fixed a

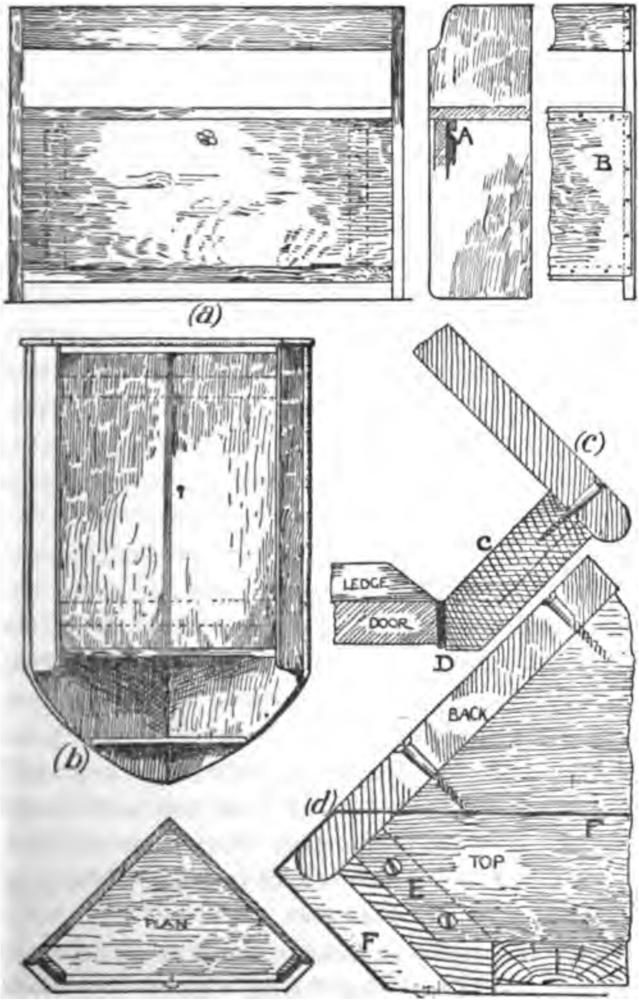

Fig. 26.—Medicine cupboards.

rebate must be cut in the back edges of the ends, bottom and shelf, to take the back board. A rebate is also cut for the top rail, 3 in. wide. Fig. 26, B, shows the back and rail screwed in. The door, or flap, is made of one piece, which is kept flat by ledges, indicated by dotted lines in Fig. 26, *a*, screwed to the back. Brass butt hinges 1½ in. long are cut and screwed into the bottom edge of the flap and the bottom of the cupboard. The flap should shut up against a fillet (marked A in Fig. 26, *a*), the ledges being cut away to pass it. A brass cupboard-turn is the simplest form of fastening, and a thin chain, fixed to flap and cupboard, will support the flap when open.

The next cupboard (Fig. 26, *b*) is for hanging in a corner, and it has two doors. Its shape makes the construction a little more difficult than that of the cupboard already described, but there is nothing to frighten an amateur. The wood is all ½ in. thick, except that for the two corner uprights, which are of ¾-in. stuff. The extreme height of the cupboard (Fig. 26, *b*) is about 2 ft. 3 in., and the back boards on the plan are 14 in. deep from back to front, and about 18 in. wide over all in front. Uprights, 2 in. wide; doors, 7 in. wide.

Make the top and the bottom first. These can be cut " one in the other " from a board 9 in. wide, and the grain running parallel to the front edge, as seen in the plan. Then the two back boards

should be planed and shaped, and their front edges rounded. One of the boards will be ½ in. narrower than the other, to allow for the overlapping at the back corner. Fig. 26, *c*, shows the shape of the upright, C. It is planed off square at D to allow for the hinging, as well as to give a flat face on the front. The larger plan (Fig. 26, *d*) shows the top with the front corner cut off square to the back edge. The corner is let into the top of the upright and screwed as seen at E.

When all the above-named parts have been prepared, the back boards should be screwed together, and then screwed to the top and the bottom, the uprights being fixed last. These are attached to the back and top by screws, and by nails to the bottom. The doors are ledged and hinged as shown at D. A half-round slip is pinned on to the right-hand door to cover the joint where the doors meet. If a shelf be fixed inside the cupboard, the left-hand door can be fastened with a small hook and eye. The hook is screwed to the shelf, and the eye to the door. If a shelf be not needed, a small bolt will be necessary to keep the door shut. A lock or cupboard-turn should be used on the right-hand door. In the angle under the bottom there is room for a small shelf, which can be screwed through the back boards. To give a finish to the cupboard, a piece of ½-in. wood, wide enough to cover the corners, is fixed on the top. The edges, rounded,

project far enough to cover the front edges of the back boards. This piece is indicated by a thick line on the plan (Fig. 26, *d*) at F F. Two large glass-plates screwed to the back and nailed to the wall will support either of these cupboards.

A MUSIC AND MAGAZINE CUPBOARD.

This cupboard is specially designed to hold the ordinary sheets of music in one half, and magazines and papers in the other. Front and end views are given in Fig. 27, *a* and *b*. It is 3 ft. 6 in. high and 2 ft. 10 in. wide ; the depth, on the outside of the end, is 15 in., sufficient to allow for a sliding tray, in which the music can lie flat. Oak, mahogany, or walnut is a suitable wood for such a cupboard ; or whitewood, if a softer timber be desired.

It is assumed that the maker of this article will know something of the joints used in its construction, so that a detailed description of them is unnecessary. The top and bottom, of $\frac{3}{4}$-in. wood, are dovetailed into the ends. The dovetails are shown on the half-plan (Fig. 27, *c*). The central partition, 1 in. thick, is tenoned into the top and bottom —also shown on the half-plan. The back, of $\frac{3}{4}$-in. framing and two three-ply panels, is rebated into the ends, as shown at the top of Fig. 27, *c*.

The finished top projects over the front far enough to cover the thickness of the doors, and is

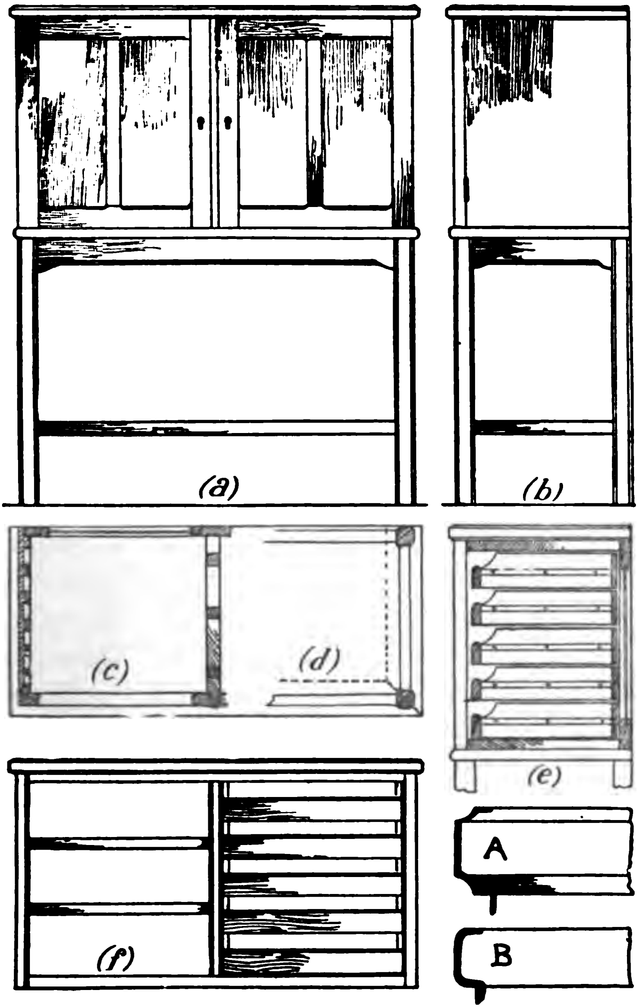

Fig. 27.—Music and magazine cupboard.

screwed on from underneath. A suggestion for a moulding round the edges of the top is given half full size in the diagram A. Fig. 27, *f*, is a front view of the cupboard without the doors. On the left are shelves, and on the right are the music trays. Shelves and trays are supported on grooves cut right across the ends—an old-fashioned but good method—before the cupboard is finally glued up. As the doors shut on the front, the grooves are not seen. In the shelf cupboard they are $\frac{3}{16}$ in. deep and wide enough to take the thickness of the shelf; in the tray cupboard they are the same depth and $\frac{3}{8}$ in. wide to take the slips screwed on to the sides of the tray (see F, p. 81). The two grooves for a tray are opposite the middle of the sides. In Fig. 28, D, is shown the centre partition rebated on both sides of the front edge to take the doors when they are shut. Like the grooves, the rebates must be worked before the cupboard is glued up. Fig. 28, D, shows the doors closed into the rebates, and the half-rounded front edge of the partition. When the glue is dry and the back fitted and screwed in, the trays should be made; the fronts of 1-in. and the sides and back of $\frac{1}{2}$-in. wood. The bottom may be of 3-ply wood $\frac{1}{4}$ in. thick. The front and back dovetails of the tray are shown half-size in G, the position of the bottom being indicated by the dotted lines. The front of a tray is narrower than the side, and the

top edge is rounded. The top front corner of a side is usually shaped as shown at G.

When the trays have been made and fitted into the cupboard, the slips are fitted into the grooves to move easily, and are screwed to the side of the tray. Fig. 28, F, shows the side of the tray with

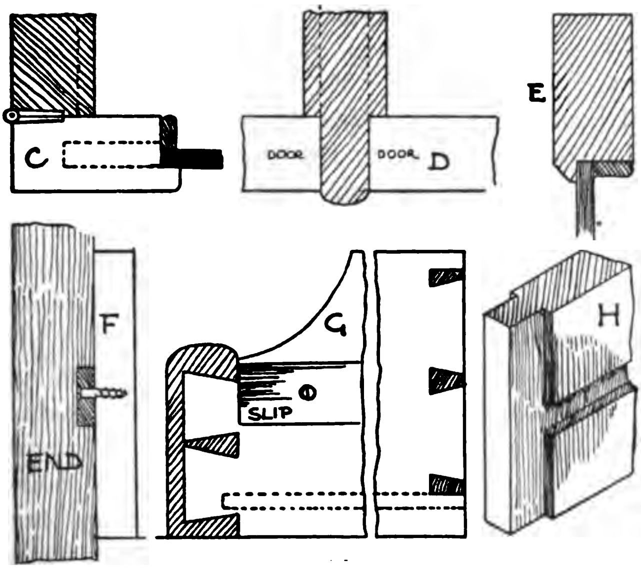

Fig. 28.—Details of music and magazine cupboard.

the slip screwed on, and running in the grooved side of the case. The section (Fig. 27, *e*) shows five trays, 3 in. deep, spaced ½ in. apart.

The shelves in the other cupboard must be fitted into the grooves so as to run easily and be interchangeable.

The doors are frames with long and short shoulder joints (Fig. 11, *a*, *b*) filled in by two panels. Stiles and rails are $1\frac{1}{2}$ in. wide, and the centre upright—or muntin, as it is called—is 1 in. wide. Top and bottom rails are bevelled on the inside edges, the bevel running out at the corners with a curve ending against the stile. A half-size section of the bevelled rail, with the panel beaded in, is given in Fig. 28, E. The doors are hinged on to the ends with brass butt hinges. The position of a hinge is given in C, which also shows the place of the tenon in the stile. Locks or cupboard-turns will be necessary to fasten the doors.

The *stand* is about 2 ft. high. The legs are $1\frac{1}{2}$ in. square, bevelled on each corner. The top rails are $2\frac{1}{2}$ in. wide and 1 in. thick. Their position in the legs is marked in the plan (Fig. 27, *d*). They are shaped along the bottom, and a bevel is worked on the edge and run into the round end. The lower rails, 1 in. wide and $\frac{3}{4}$ in. thick, are carried round the four sides. Between the stand and the cupboard is a piece of 3-in. wood about three inches wide and rounded on the edge, as in Fig. 27, B. This piece is mitred at the corners and screwed to the stand (Fig. 27, *d*).

Chapter V.

THINGS FOR THE STUDY.

Hanging Bookcases—Standing Bookcases—Double Bookcase—Bookcase with doors—Bookcases fitted into recesses.

HANGING bookcases are generally small, as there is a limit to the supporting power of a nail or a bracket. Their construction may be carried out in three ways. The sides may be (1) nailed or screwed to the shelves; or (2) housed and nailed or screwed; or (3) tenoned through and wedged. The last method is the strongest and most workmanlike, but takes most time.

The shelves may be of any wood, hard or soft; and be painted, stained, or left their natural colour.

Fig. 29, *a*, shows a simple tier of shelves, 2 ft. long, 7 in. deep, and 8 in. between shelves. The thickness of the wood is ¾ in. throughout. The end views, A and B, are alternative designs for the ends, and show the shelves mortised through. Fig. 29, *b*, gives a variation in the arrangement of the shelves to suit books of different sizes. The bottom shelf

is 5 in. wide, the middle 6 in., and the top 7 in. C and D are alternative ends.

The bottom case (Fig. 29, *c*) is a little more elaborate, having a back and double top, and an upper shelf divided into four parts for the display of vases. The under top is dovetailed down into the sides, and the back edges of the sides are rebated to take the back, which may be a three-ply panel screwed in. The divisions are fixed by screws through the under top and the shelf; the outer top is moulded on the edges and fixed by screws put in through the under top. The shaped pieces in the divisions stand back about $\frac{1}{8}$ in., and are glued in place. An end view, showing sides of the same width all the way down, appears at E. In F the sides are narrowed for the two lower shelves to make the case a little lighter and more suitable for small books.

Cases of a similar kind, but made of thinner wood—$\frac{1}{2}$ in. thick at the most—and having narrower shelves, are excellent for displaying Gosse and other china.

STANDING BOOKCASES.

These may be either single, to take one row of books on a shelf and stand back to the wall; or double, to accommodate two rows and stand at right angles to the wall or in any part of the room. A *single* case is shown in Fig. 30, *a*.

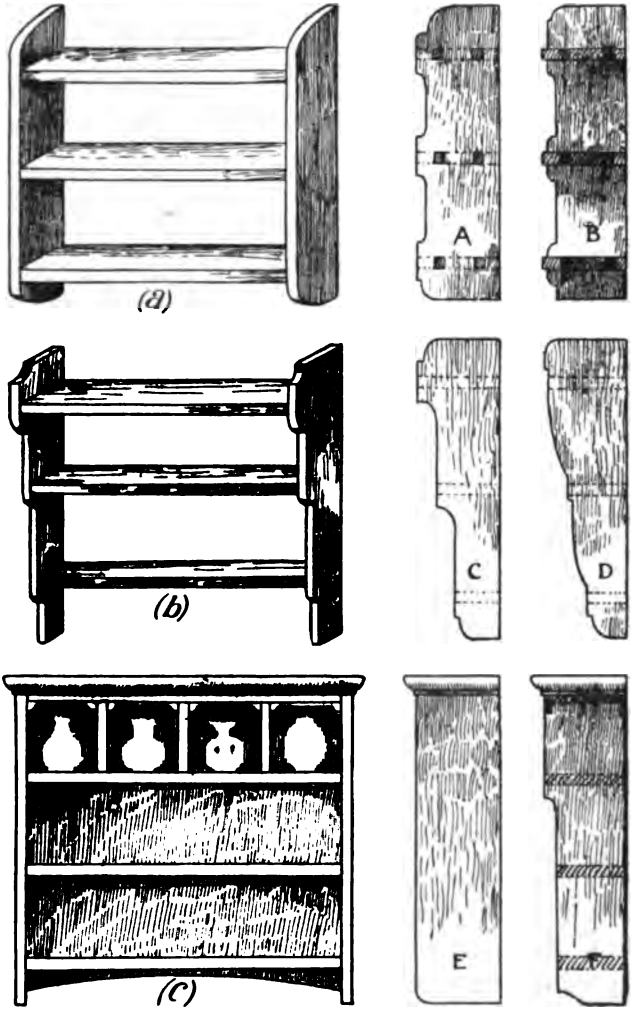

Fig. 29.—Hanging bookcases.

Material.—Oak, walnut, whitewood, or pine, 1 in. thick (finishing about ⅞ in.) and 9 in. wide, for shelves and sides. The boards should be bought ready planed. Three-ply wood for back.

Dimensions.—The shelves are only 8½ in. deep, to allow for the insertion of the back; and should not be more than about 2 ft. 8 in. long, or they will tend to droop at the middle if heavily weighted. The sides are 9 in. deep; their height will, of course, depend on the number and spacing of the shelves. The spacing, in turn, is governed by the general size of the books to be accommodated; and one may point out here that it is a great mistake to set shelves too close together, owing to the lack of standardization in the size of books, and to the fact that, if books be arranged according to subject, their heights will be found to vary considerably.

The strongest and best method of fixing in the shelves is undoubtedly the tenon and mortise, so this will be described first. Assuming the boards to be already planed up, the first thing to do is to "set out" or mark off the length of the shoulders on the shelves. This is best done by fixing the shelves in the bench vice, front edge uppermost, and then squaring a line across a full inch from one end. From this line measure off the distance, 2 ft. 8 in., to the other shoulder, and square another line across. Then remove the shelves from the vice, and from the lines already marked square

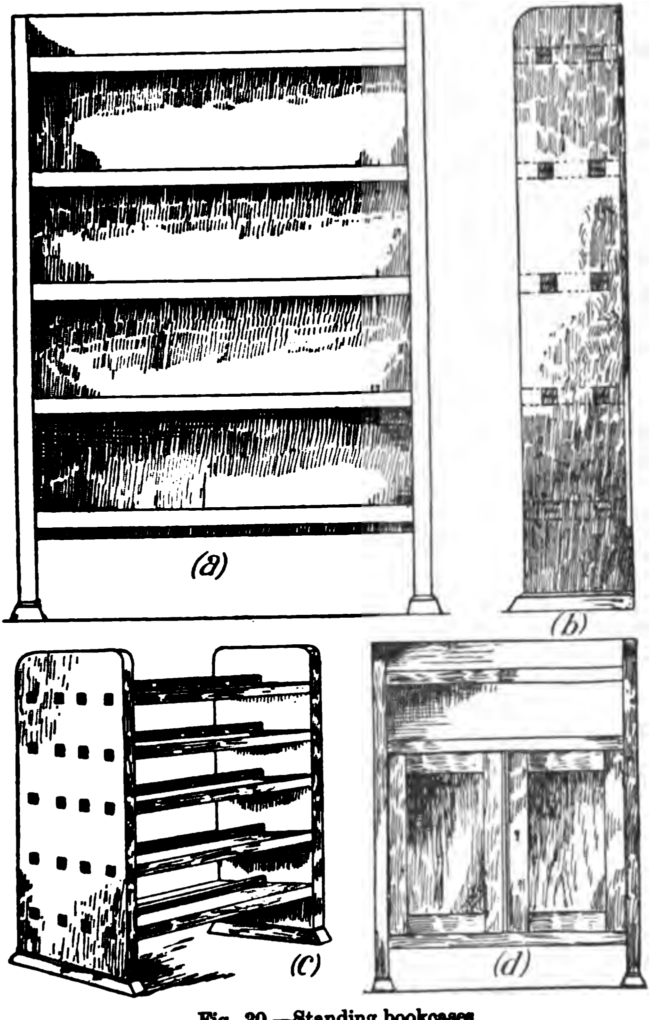

Fig. 30.—Standing bookcases

another across the top and bottom sides and the back edges. The lines for the positions of the shelves on the ends must be marked in a similar way.

When this has been done, take one of the shelves and mark the position of the tenons in pencil. Then set the marking gauge to the nearer side of the tenon nearer the front edge and mark round the ends of each shelf, and on the outside and inside of the sides of the case. Then shift the gauge to the inside line of the tenon and repeat the marking on shelves and ends as before. Do the same with the back tenon, always taking care to do all the gauging from the front edges. Next, cut the tenons down outside the gauge line, and saw out the front and back shoulders. The centre waste piece is chopped away with mallet and chisel.

To cut the mortises, lay the side on the bench and bore a hole, with a centre or twist bit, in the middle of the gauge marks and right through the wood. Then chop away the corners up to the lines, but not beyond them. Half the thickness of the end must be chopped through from one side, and then it should be turned over and the chopping finished from the other side (see Fig. 3, *f*). When the mortises are completed, the shelves can be fitted in and numbered. The shelves and the insides of the ends must then be finally cleaned up, and a cut made with the saw down the middle of the

tenon to take the wedge. The cut is about two-thirds the length of the tenon, and parallel to the side of the shelf.

The *wedges* are cut out of the same kind of wood as the ends. They should be 1¼ in. long, a little wider than the tenon, and ¼ in. at the thick end. There is one more thing to do before the case is glued—to cut a rebate ½ in. deep and wide in the edges of the ends to take the back of three- or five-ply panel. The rebate may run from top to bottom, or be stopped, as Fig. 30, *b*, shows. When the rebate has been worked the case can be glued up. Both tenons and mortises need a little glue. All the shelves should be knocked into one end first, and then the other end knocked on to the shelves. The work must be done quickly, to prevent the glue chilling before the end and the shelf fit up to each other. A blow with the mallet on any odd piece of wood, laid between the tenons, will ensure a good joint, but if possible cramps should be used. The wedge must be glued and driven in slowly, as there is a danger of splitting the shelf inside. It is not necessary to drive the wedge right in, but only far enough to spread and tighten the tenon.

When all the wedging is done, the top shelf and ends should be tested with a 12-in., or larger, square, and the whole thing pushed into the right shape if not quite rectangular. Then the back

should be fitted and screwed into the rebate and along the top, bottom, and centre shelves.

The front edges and the ends will need cleaning off, and the top of the ends slightly rounding, as in Fig. 30, *b*. The last thing to do is to screw on the "floor-pieces" or shoes, of 1½-in. stuff, slightly bevelled on each side and the front end. They give a more solid look and base to the case.

A quicker method of making this bookcase is to "house" the shelves in and nail them from the outside. Still quicker, but not so effective, is mere nailing or screwing from the outside. In both methods the setting-out would be similar.

THE DOUBLE BOOKCASE.

Fig. 30, *c*, is made on exactly the same principle, except that there is no back to it. The shelves are 14 in., 16 in., or 18 in. wide. A slip ¾" × ½" is screwed along the top side of each shelf, to prevent the ranks of books touching each other. The sketch represents the slip in the centre, but it can be fixed to fit the depth of the books.

BOOKCASE WITH DOORS.

The shelves and back in this case should be tenoned and rebated as in the first-described example, but the shelves inside the cupboard may rest on fillets screwed to the ends, and must stand back from the front to the extent of the thickness

of the doors. The doors are hung with 2-in. brass butt hinges cut into the stile.

Where the doors meet in the centre, they are rebated one into the other. A "neck" bolt should be screwed on the inside of the left-hand door just above one of the shelves, so that the bolt can drop into a hole in the shelf. A lock or cupboard-turn is fitted to the right-hand door.

The doors shown in the drawing are made with a long and short shoulder joint, the panel being beaded into the rebate. If solid doors be preferred, they must be braced at the back with a dovetailed clamp (Fig. 9, *a*).

BOOKSHELVES FITTED INTO A RECESS.

A recess can be easily fitted with bookshelves which do not require fastening to the wall. The boards to make the ends and shelves should be 1-in. stuff, and the fillets to support the shelves $1'' \times \frac{3}{4}''$.

The two ends are laid together and squared across to mark the positions of the fillets, which are screwed on with three screws apiece. The ends rest on the skirting, as in Fig. 31, *a*. When they are in position, measure off the distance between them very carefully, and cut each shelf a trifle too long, so that it shall need sufficient forcing into place to keep the sides tight against the wall. Each shelf should be measured off

separately, as the sides of the recess may not be quite parallel.

A shelf more than three feet long is inclined to sag, and nothing looks worse than such a shelf overweighted with books. To prevent this, a loose

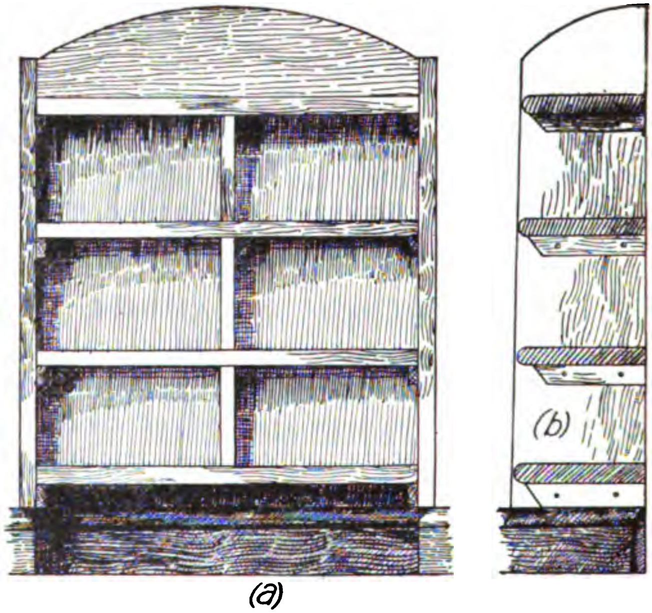

Fig. 31.—Bookcase for recess in wall.

piece is fitted between every two shelves. This can be shifted sideways when books do not fit in exactly, and the bottom shelf is supported by a similar piece reaching to the floor.

The front edges of the shelves can be rounded off

if desired; and the fillets look better if their front ends be shaped and kept back about half an inch from the front (see the end section, Fig. 31, *b*).

The advantage of a series of fitted shelves is that they are not a fixture, and may be adapted to another recess in case of removal.

Chapter VI.

THINGS FOR THE NURSERY.

A Doll's House—A Doll's Cradle—A Child's Chair—A Child's Table—A Chest for Toys—Humpty-Dumpty.

THIS chapter describes a few articles which a boy can easily make for his small sisters, and which will be very nice presents for small friends.

A DOLL'S HOUSE.

A doll's house should be raised 12 in. to 18 in. from the floor, so that a child may either sit or stand to play at it. The simplest form of house is a box with a sloping roof added (Fig. 32, *a* and *b*). The drawing shows one 2 ft. 6 in. long, 2 ft. 6 in. high, and about 12 in. deep. It is made of $\frac{1}{2}$-in. whitewood throughout, except the back, which is a three-ply panel nailed on. When the ends have been bevelled off to the slope of the roof, they must be nailed to the bottom and to the middle pieces, which constitute the ground and the first "floors" respectively. The front edges of these two floors are kept back about $\frac{5}{8}$ in. from the front of the ends,

to allow for the thickness of the doors. The back is next nailed on. The upright partitions between the rooms are shown by the dotted lines in the drawing. They should be fixed after the back. The lower is nailed to the ground and first floors;

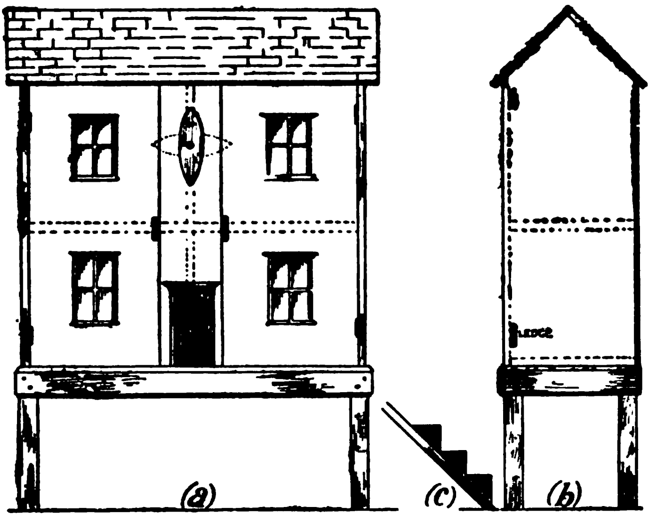

Fig. 32.—A doll's house.

the upper one is nailed through the back and skew-nailed from the front into the first floor.

One of the roof boards, which project about 1 in., laps over and is nailed to the other at the ridge, and both are securely nailed to the sides.

The front of the house is divided into three parts. The centre is a piece 5 in. wide, nailed on to the

floors and partitions. This piece gives an opportunity for displaying a "dummy" front door, made of thin ½-in. strips glued on. It also provides a place for fixing on a button to hold closed the real doors, which, when open, expose the upper and lower rooms to view.

Each door is made out of one piece of board braced at the back with a ledge (Fig. 32, *b*). Butt hinges are used to hang the doors, which are fastened by the button, and pulled open by a small block screwed on from the inside of the door. The outside edge of the block is planed off to a sharp bevel to afford a hold to the fingers. The windows are made by cutting holes, and gluing thin strips of ½-in. wood round them, the sash bars being halved together. One piece of glass should be fixed to the door behind each window. A staircase is quickly made by gluing angle blocks on to a piece of ½-in. wood, as seen in Fig. 32, *c*.

The walls of the house should be painted white, the windows and dummy door green, and the roof a brick red, with darker red lines for the tiles.

Legs for the stand are 1½ in. square. Battens 2½ in. wide are nailed to the outside faces of the logs to form the frame, to which the house should be securely screwed.

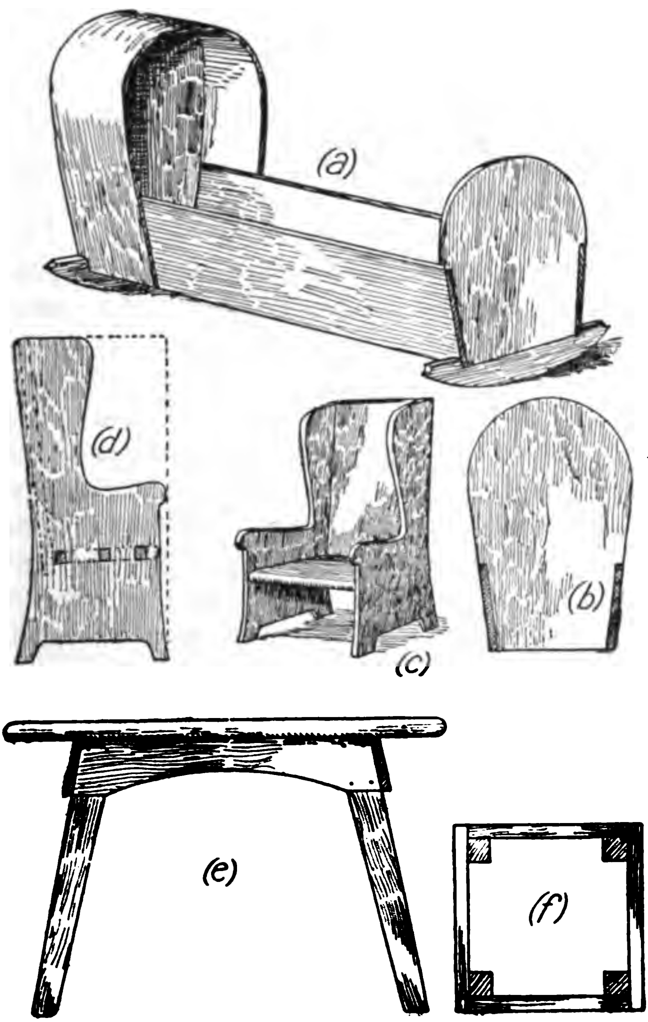

Fig. 33.—(*a*, *b*) Doll's cradle; (*c*, *d*) child's chair; (*e*, *f*) child's table.

A DOLL'S CRADLE.

This cradle (Fig. 33, *a*) is a model of the old Dutch type, and very simple to make. Outside measurements: length, about 2 ft.; width, 11 in.; depth, 6 in.; height, 16 in. at the head and 13 in. at the foot. The hood is 5 in. wide. It is made of ½-in. pine, whitewood, or deal, and will take a full-size, or "long-clothes" doll. The ends should be notched out, as shown in Fig. 33, *b*, to allow the sides to lie flush. Fix the bottom by nails driven through the ends, and then nail the sides to the end. The hood is made out of a cheese-box, the wood of which will bend easily, especially if it be wetted. The ends taper slightly towards the bottom, making the shape a little more quaint than it would be if they were square-cornered. The rockers are screwed on from underneath. Painted a good red or green, and simply decorated in Dutch fashion, the cradle makes a delightful toy for a little girl.

A CHILD'S CHAIR.

Fig. 33, *c*, illustrates a small chair which can be made out of four pieces of ¾-in. wood—either oak or pine. It need only be 24 in. high, 12 in. wide, and 12 in. deep. The seat slopes towards the back, and is tenoned right through the arm-pieces and wedges; the back is attached by screws

through the ends, the holes being filled up with plugs of the same kind of wood, or round-headed projecting brass screws might well be used, as they are not at all unsightly. The seat is 11 in. from the ground, and the arm lines 6 in. above the seat. All edges should be well rounded off. Fig. 33, *d*, is a side elevation, showing in dotted lines the back and the sloping seat.

A CHILD'S TABLE.

This is a low table, fit for a child to sit at in a low chair for its meals or games. It should be about 20 in. or 24 in. square and 18 in. to 20 in. high. The 2″ × 2″ legs should taper downwards, and spread about 1¼ in. The top hangs over 2 in. all round. The framing, 3½ in. deep and ⅝ in. thick, can be nailed to the outside of the legs; and the top, composed of two boards, may be nailed down or screwed up from the inside (Fig. 33, *e*).

A small fillet fixed round three top edges prevents things falling or being pushed off behind. A plan of the legs with the frame nailed on outside is shown in Fig. 33, *f*.

A CHEST FOR TOYS.

This chest is a sort of low cupboard, simple to make and suitable for a child's use. It is a really nice piece of furniture if some care be taken over

its manufacture. It has no lid to fall and crush fingers nor hinges to be broken off, will serve as a table for games, and, when toy days are over, should make a useful linen or hat cupboard. The length is 3 ft., the height 2 ft. 4 in., and the width from back to front 18 in. American whitewood is the best wood, as very wide boards can be obtained ready for use. The ends, top, and bottom are made of 1-in. stuff, and the back and front parts of ¾-in. The front elevation, plan, and section are shown in Fig. 34, *a*, *b*, and *c* respectively.

The first thing to do in making the chest is to groove the ends to take the bottom, which diagram B shows half full size. The groove is 7 in. from the floor. The bottom must project ¾ in. beyond the front edge of the ends, as seen in diagram C, to support the sliding doors. The back edges of the ends are rebated to take the back board, as at A, the rebate stopping just below the groove for the bottom. The stop is marked D in Fig. 34, *c*.

When the back and bottom have been fitted, they are nailed to the ends; and the back board is nailed, along its length, to the bottom. The edges and corners of the top should be rounded, as shown, before it is nailed down. It projects over the chest all round, ¾ in. at the back and ends, and 2¼ in. at the front.

To make a platform for the doors to run upon, the bottom has been extended beyond the front

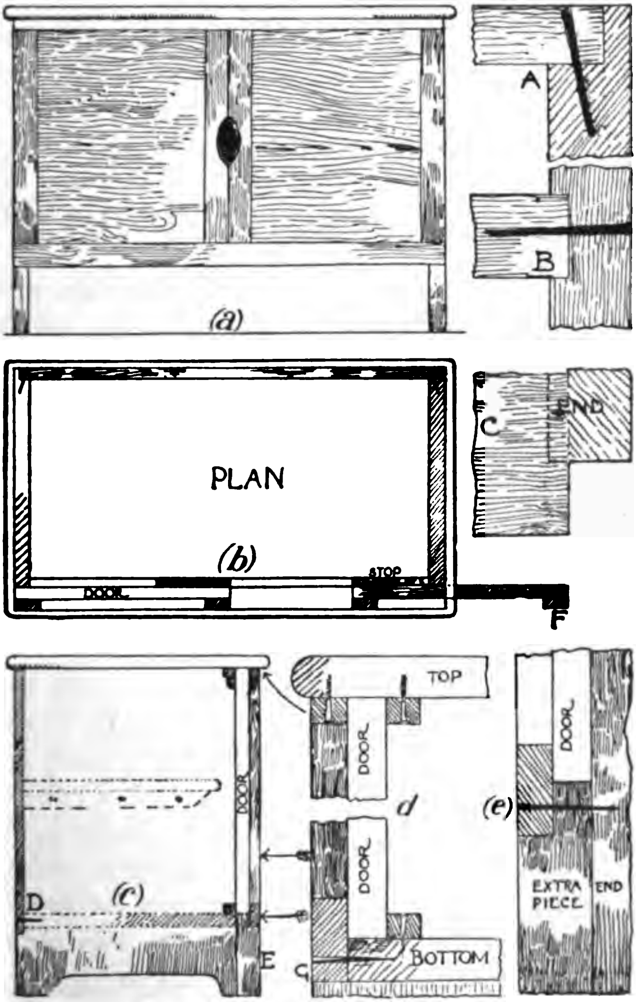

Fig. 34.—Chest for child's toys.

of the ends. This necessitates fixing an extra piece on the end to bring it flush when the door is fitted. This extra piece is shown in Fig. 34, *e*, and its exact position at E in Fig. 34, *c*. A little bit extra must be cut off the bottom board to allow this piece to be fixed in its right place with nails and glue.

The boards for the *doors* are 19½ in. wide, and of ¾-in. wood. (It is quite possible to get boards of that width.) To keep the doors flat, a 2″ × ¾″ clamping-piece is screwed on the front at each end, the screws being put in through the doors. These clamps are seen in the elevation (Fig. 34, *a*), and at F in Fig. 34, *b*. The doors run between guide-slips. Two are screwed up under the top (see Fig. 34, *d*), one screwed to the bottom board, and one, 1¾ in. wide, nailed on the front edge of the bottom (Fig. 34, *c*, G). The clamps must have a piece cut off at each end equal to the thickness of the slip in order to run between the slips. The plan (Fig. 34, *b*) shows one door open. To prevent it going too far, a piece of ¾-in. wood 6 in. long is screwed to the inside underneath the top slip. This piece is shown in contact with the end. So that the doors may be opened, an oval hole is cut right through the two centre clamps, as indicated by heavy shading in Fig. 34, *a*.

One or two shelves can be fixed on fillets screwed to the ends.

HUMPTY-DUMPTY, THE TUMBLING MANNIKIN.

This amusing little toy can be made at trifling cost with the assistance of any one who can use a needle.

In the centre of a strip of cartridge paper, 7 × 4 inches in size, sketch a man's face, the two ends of the strip being darkened with the "hair," which should also outline the forehead. When the ends—slightly overlapped—are sewed together to form a cylinder, with very small stitches of cotton matching the hair in tint, the join down the back of the head will be practically invisible.

Next collect some scraps of print materials with which to clothe him. Cut out two rounds 5½ inches in diameter for the "cap" and "vest." Turn the edges in and gather them closely; then sew them to top and bottom of the cylinder about half an inch up, that the paper may not tear away. Before finishing off the second round, slip in a small, heavy rubber ball (the only thing which need be bought on purpose, assuming an old golf ball not to be available) about 5 inches in circumference. It is this weight which causes "Humpty-Dumpty" to tumble off his wall when it slopes too steeply!

Now fashion the little two-tailed coat, 4 inches deep from neck to end of tails, shown in Fig. 35, and catch it round the neck of the mannikin with a few stitches. Make it small enough to be open

in front, and $7\frac{1}{2}$ inches wide when turned in and run finely (hemming will make it too solid at the edges). Sew a tiny glove button on the right front, and two more to match just above the division of the tails—which should be button-holed round to prevent splitting. The sleeves are narrow strips 3 inches long, seamed up, turned right way out, pressed flat, and sewn on about half-way up the coat. The trouser legs are similar, but a good size larger, and are seamed on to the centre of the lower round—touching each other at the top.

Finally, cut out "boots" from an old kid glove, doubled so that there is no join at the back, and button-hole the edges together very finely all round; then sew them inside the trouser legs. "Gloves" can be made in the same way, or paper "hands" (tinted like the complexion) may be attached inside the sleeve wrists instead. A tie of "baby" ribbon can be put under the chin as a finish; and it is easy when painting the face to simulate collar ends by outlining them on the paper and leaving it white.

Humpty-Dumpty is now quite ready to display his accomplishments as soon as a stage has been provided. For this purpose, lean a large screen against the edge of a table, and cover it with a rug or a woollen table-cloth (not a rough one). Seat the mannikin at the top of this inclined plane and loose him. The ball at once begins to run

Fig. 35.—Humpty-Dumpty.

through the cylinder, and turns him head over heels again and again till he brings up—generally with a somewhat vicious kick !—upon the floor.

The little gentleman may be dressed in all kinds of picturesque colourings. Scarlet and white mixtures for cap, coat, and legs, with turkey twill "vest," are effective. It is amusing, also, to clothe one in Oxford and another in Cambridge shades and to let the rival "blues" race each other down the screen. They sometimes kick at or "foul" each other in a rather unsportsmanlike manner, though as a rule they tumble amicably side by side.

Chapter VII.

THINGS FOR THE KITCHEN.

A Cheap Meat Safe—An Ice Cabinet—A Hot Chest—A Drying-rack—A Fireguard and Clothes-drier.

THE meat safe shown in Figs. 36 and 37 has for its overall measurements: height, 2 ft. 6 in.; width, 1 ft. 9 in.; depth, 20 in.

It is built up of planed slating battens measuring, when finished, ¾ in. by 1¾ in., and ⅜-in. boarding for the bottom and part of the top.

The bottom and top overlap the sides. The back is merely an X-shaped double strut to give lateral stability. The sides are strutted from corner to corner to prevent the front sagging if the safe be hung on a wall. All crossing joints are "halved."

Construction.—Begin by cutting out the pieces for the sides—four 29½ in. long and four 20½ in. long. Lay all pieces of the same length together on the bench, and square lines across the lot to mark the positions for the shoulders of the halved joints. These should be such a distance apart as

to leave a little spare wood at each end for subsequent cleaning-off. The marking gauge is then set to half the thickness of the wood, and the saw

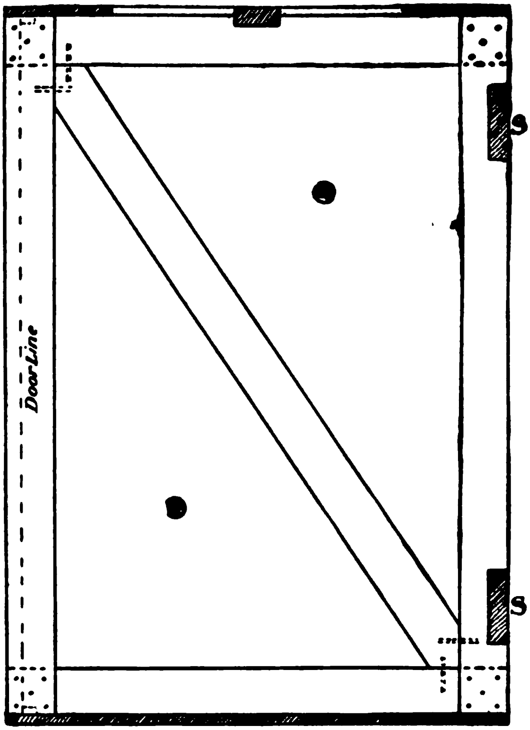

Fig. 36.—Side frame of meat safe.

lines scratched on two edges and the end of each piece. Cross-cut along the shoulder marks with a fine tenon-saw down to these lines, and then slit the pieces down to meet the shoulder cuts, just

not cutting out the lines. The four pieces of a frame are then assembled, a wire nail driven through each joint, the frame adjusted to get the angles square, and the nailing completed. Clinch all the nails carefully.

The second frame is put together on top of the first to get the two as similar as possible in shape.

The struts are now marked off from the frames —a fine point being used for the purpose—and cut out, the saw being held quite squarely and applied outside the marks. The struts should make a tight fit without distorting the frames, to which they are attached by decapitated wire nails driven in obliquely through holes pierced in the struts with a drill or bradawl.

The spare ends of the frame pieces are now chiselled off flush, and the frames temporarily nailed together, with struts coinciding, for planing along the edges to get their shapes exactly similar. Three 21-in. pieces of 10-in. by ⅜-in. board are cut off, and one of them slit down the centre. Nail the unslit boards lightly to what is intended to be the bottom of the frames (after due consideration of the run of the struts relatively to the front), and the two narrower pieces to the top. In the centre of the top edges must be cut two nicks deep enough to let the centre bar sink in level with the top pieces. Fix the bar with a screw at each end.

The Back Struts.—Turn the framework back upwards, and make guide marks (Fig. 37, A A A A) on the outside corners of the uprights 3 in. from each end.

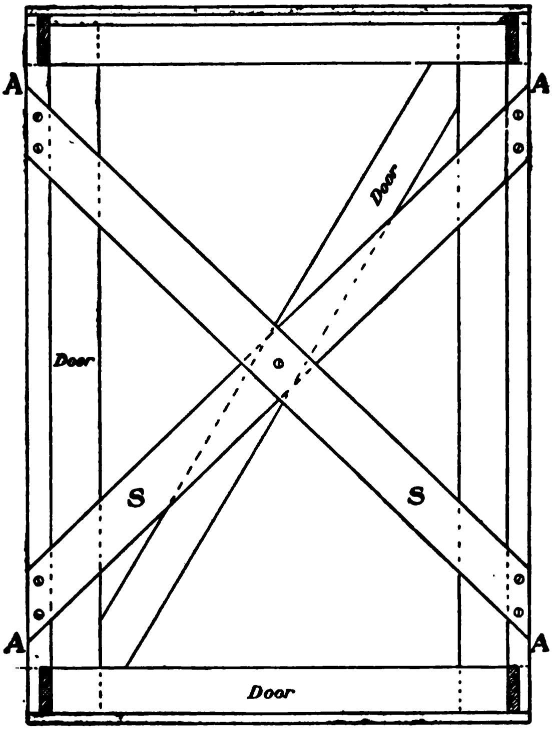

Fig. 37.—Back frame of meat safe.

Lay a batten obliquely across the back up to two of these marks, and cut it off roughly to measurement. Tack one end to the framework, adjust the framework angles to right angles, and tack

the other end. The notches on the back of the side frames are then marked off, also the cutting lines on the batten.

Remove the batten, mark the notches to full batten depth, and cut them out with saw and chisel. Cut the strut to shape at the ends and tack it in place again. The other strut may then be laid over the first to get the position of the notches and the halved joint at the point of intersection. When the necessary notching has been done, the struts are put in place and secured by two nails or screws at each end and one at the crossing point. Clean up the ends of the struts, and complete the nailing of the top and bottom boards. Nail slips of wood along the tops of the sides between the centre and back and front bars to make the top edge level all along, and glass-paper all outside corners and edges to a reasonable smoothness.

Nail slips inside the safe ten inches from the bottom to serve as ledges for a shelf.

The door is made in the same way as the sides, with a single strut. It should be a trifle large to begin with, to allow for planing down to get a neat fit inside the front. Butt hinges one and a half inches long will be strong enough to carry its weight. When the door has been hung, lay the framework on its face, and nail ½-in. by 1-in. strips to the framework, touching the door all round.

Covering the Safe.—The cheapest covering and the easiest to attach is mosquito netting, held up to the inside of the framework by thin slips of wood screwed on. One piece will be needed for the sides and back, and smaller pieces for the door and top. This material gives good ventilation and excludes flies, but is not, of course, proof against mice, to balk which a metal protection is needed. Iron gauze has the disadvantage of rusting in a damp atmosphere, while copper or brass gauze is much more expensive. The perforated zinc made for the purpose is, all things considered, the most satisfactory covering.

Fittings, Hangings, etc.—The top cross-bar should be provided with two or more hooks for the suspension of joints, game, etc.; or a bar for hooks should be fixed an inch below the top. A grid form of shelf is most suitable.

If hung on a wall, the safe should be prevented from touching it, so as to allow ventilation through the back.

Modifications.—If perforated zinc be used, the struts on sides and door and back may be dispensed with; but in this case zinc should be nailed to the sides before any strain is put on the frames, to prevent distortion. The back struts may be replaced by vertical boards six inches or more wide, space being left between them for proper ventilation.

HOW TO MAKE A CHEAP ICE CABINET.

In very hot weather an ice cabinet is invaluable for the storage of perishable provisions, and of such things as butter, which, if not actually injured, are rendered less appetizing by heat.

The apparatus to be described can be constructed at small cost, and will probably meet the requirements of many households.

The *materials* needed are :—

A Tate's sugar-cube box.
50 ft. run of 4-in. by ¾-in. matchboarding.
20 „ „ 4-in. by ⅝-in. „
17 „ „ 2-in. by 2-in. battens, ready planed.
8 „ „ 2-in. by 1½-in. „ „
14 square ft. sheet zinc.
A good supply of 1½-in. nails and thin screws.
For insulation, 20 lbs. of slag wool, or *dry* sawdust sufficient to fill the spaces between the skins.

Construction.—Fig. 38 is a plan of the top of the chest immediately under the lid. Fig. 39 is a vertical longitudinal section through chest and lid.

The inner wooden case is a sound Tate's sugar box, which outside is 20½ in. long, 15 in. wide, and 17½ in. deep without the lid. Any box of good size will serve equally well, but we choose this particular kind as it is easily obtainable and at a much lower cost than an equal quantity of uncut wood.

The first operation is to screw or nail the sides securely together and to the bottom. The outside should then have brown paper or linen glued over all joints to prevent the insulating material working through. Next construct the frames A and B, either as shown in the plan or by mitring the angles.

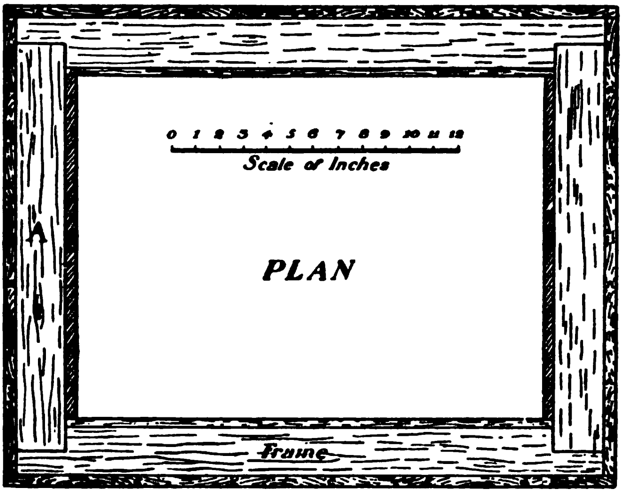

Fig. 38.—Plan of ice chest.

These frames should fit the box closely, and be screwed on flush with the top and bottom, the screws being inserted from inside. The ledges which originally held the box together will have to be removed to allow this to be done.

The Zinc Lining.—If the maker be not fairly expert with the soldering-bit, the insertion of the

lining had better be left to a professional. It is not a difficult business, however, and for the sake of the reader who may prefer to tackle it himself, the following hints are given.

The *bottom* is a tray with edges turned up half

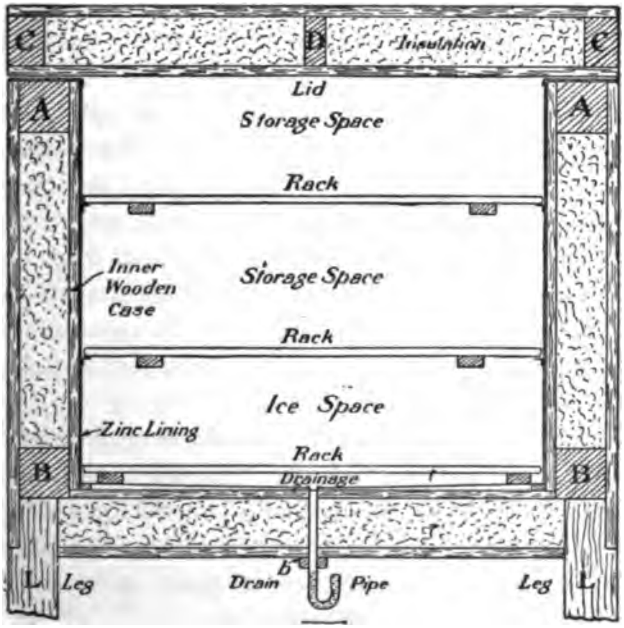

Fig. 39.—Sectional elevation of ice chest.

an inch, but not quite squarely, so that when the tray is forced into place the edges shall press against the sides of the box. Before inserting the tray bore a half-inch hole in the centre ; beat the edges of the hole slightly downwards to form, as it were,

the top of a funnel; and nail in the angles of the box narrow slips of quarter-inch wood, so that when the tray is subsequently drawn down by the drainage pipe all water will run to the centre.

The *ends* are two pieces half an inch deeper and one inch wider than the box. The bottom and side edges are turned in half an inch. Push the ends into place inside the bottom.

The *back and front* are just large enough to fit inside the parts already in position. The bottom edges should turn out half an inch, and the other edges be pierced with small holes (from which the burr must be filed away), a quarter-inch from the margin. These holes are for small brass tacks to hold the back and front tight up to the box, or the metal between them and the box, and to make soldering easier.

All surfaces to be soldered should be well cleaned beforehand, and preferably "tinned" with the easily fused solder which should be used for making the joints watertight. During soldering the parts should be pressed together to get a good joint. Solder over all heads of tacks.

When the lining is in place it should reach just to the top of the box, unless it be preferred to make the sides long enough to lap over the top of the frame. The course outlined is only suggestive, as one of several other methods may be pursued. For instance, an end and a side, or the bottom

and two ends, might be made in one piece; but care will be needed in the bending.

The *outer case* is built up of pieces of $\frac{3}{4}$-in. matching, two inches longer than the outside depth of the sugar box. These are screwed to the frames A A, B B, the insulating spaces being filled in with sawdust or slag wool as the boards are added. If sawdust be used, the casing should be tapped to make it settle, and the sawdust should be well rammed. Matters will be simplified if slips of wood be inserted at the corners to prevent the sawdust shifting round them when the chest is turned over. Slag wool should not be packed tightly enough to crush it.

The edges of sides should project slightly in the first instance, and be afterwards planed down flush with frame, A.

The *legs* are made of 2-in. by 2-in. batten, cut back on two faces, so that the parts projecting beyond the bottom are flush with the outside of the case, which will rest directly on the legs.

The *bottom* is of $\frac{1}{2}$-in. matching, screwed to the sides, after the insulating material has been introduced. There must be square notches at the corners for the legs.

The *drainage pipe* is a piece of $\frac{3}{8}$-in. (outside) copper tubing, bent as shown, so that a water-seal is formed to prevent the heavy cold air leaking out at the bottom. Before bending the tube,

anneal it by heating it to redness and plunging it into cold water; and fill it with molten lead or resin. (This is melted and run out again after the bending has been done.) A metal or wooden collar, *b*, provided with a clamping screw, is slipped over the tube, which is passed through holes in the bottom of the casing and inner jacket, and soldered to the lining with its top flush, so as not to hold up water. Then pull the tube down to bring the lining into contact with the wood, and clamp the collar.

The *lid* is a framework, C C, and cross-bar, D, boarded top and bottom with ½-in. matching. The under side should be covered with a sheet of thin zinc, fixed on with small countersunk screws.

If the lining of the chest does not cover the frame, A, separate pieces must be fixed, with their edges bent downwards over the lining, to which they are soldered. The lid should make a good fit with the top of the chest, though an exact fit is not needed, since a little ventilation is a good thing.

The lid is hinged at the back, and connected by a chain at each end with the chest, to prevent it falling over backwards. A lifting handle should be attached to the front face of the lid and to each end of the chest.

Give the woodwork outside a couple of coats

of varnish to keep out damp and prevent swelling of the wood.

Racks.—Three racks are needed, one to carry the ice and allow it to drain, and two for the articles stored in the chest. They can be made of ⅜-in. stuff joined together by cross-pieces. To support the upper racks solder L-shaped strips of stout zinc to the ends of the lining, 5 and 12 in. from the bottom, or at any other distances which may be preferred.

The instructions given above apply, with necessary modifications, to ice cabinets of other sizes. If a larger apparatus be required, the inner jacket might well be made up of two boxes fixed end to end, and provided with separate lids, so that each part may be used independently of the other, and butter, etc., be kept apart from provisions which might taint it.

A HOT CHEST.

An apparatus to keep things *hot* may be made on exactly the same lines as the ice chest just described, excepting that the inner lining should be of sheet iron, with joints riveted instead of soldered, and that there should not be an inner wooden case, which would tend to warp under the influence of heat. Slag wool is used as insulation, being non-inflammable.

A couple of firebricks, previously well heated in the fire, should be laid in the bottom of the storage

chamber before the food is introduced, to act as a reservoir of heat. The food will then remain hot for a long time. In households where meals are necessarily unpunctual a hot chest will be found useful, as the food is not dried up as it would be in an oven, and there is a certain economy in fuel.

The joint between chest and lid should be made as airtight as possible, since the hot air rises to the top, and, if allowed to escape, will be replaced by cold air from outside, which will soon bring down the temperature of the chest.

A DRYING-RACK FOR CLOTHES, ETC.

In Fig. 40, *a* and *b* show two forms of rack which, when loaded with clothes and other articles that require to be dried, can be drawn up quickly to the ceiling of the kitchen, where it will be out of the way and get the full benefit of the hot air which naturally rises to the highest part of the room.

Fig. 40, *a*, is merely an H of 1½-in. by 1½-in. wood, with a 1½-in. by 1-in. connecting cross-bar of a convenient length, and two stout galvanized wires parallel to it. In Fig. 40, *b*, the wires are replaced by wooden rods ⅜ in. by 1½ in. (actual), with their longer faces vertical. In either case there is accommodation for three rows of clothes, etc.

From near the extremities of the ends run four

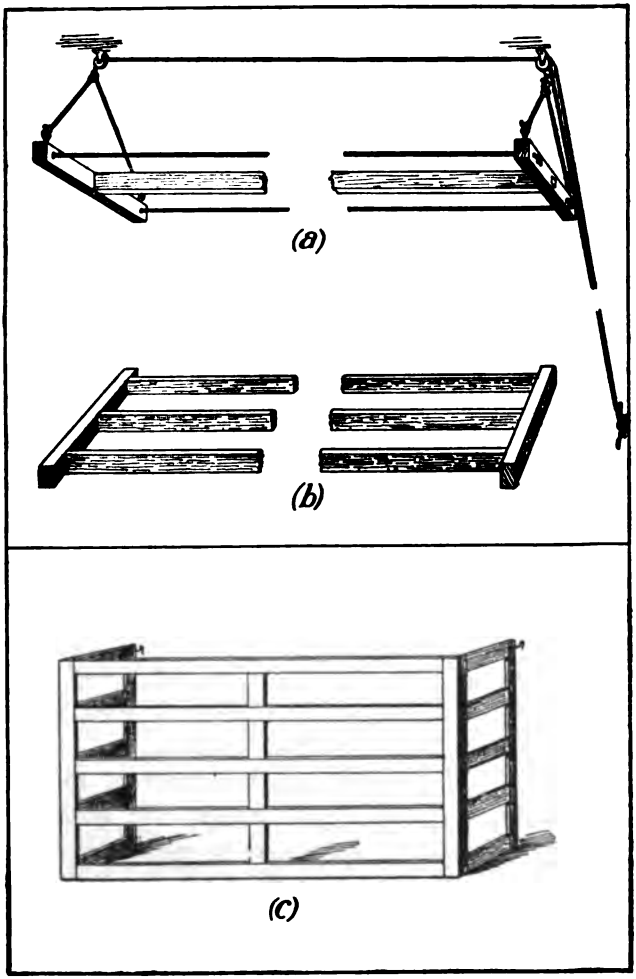

Fig. 40.—(*a*, *b*) Drying-racks ; (*c*) wooden fireguard.

short cords, which are tied on to a couple of hoisting-cords, passing over pulleys screwed into the ceiling joists. These two cords should be knotted together at intervals between their loose ends and the pulleys, so that they will keep the rack horizontal while being raised or lowered.

For appearance' sake the joints should be mortised and tenoned; but careful nailing or screwing will serve.

A WOODEN FIREGUARD AND CLOTHES-DRIER.

The guard shown in Fig. 40, *c*, is intended primarily for use in a room occupied by children. It is long and deep enough to go outside an ordinary curb, and sufficiently high to prevent a child falling over it—30 inches will be sufficient. The ends are provided with hooks to engage with eyes fixed in the wall outside the fireplace. The wings are attached to the front by hinges on the fender side—where they will be out of sight—so that when not in use the guard may be folded flat.

Ordinary $\frac{7}{8}$-in. by 2-in. slating battens, planed and rubbed down with glass-paper, will serve as material. If ease and quickness in construction be aimed at, the joints may be halved; but tenons and mortises will give a smarter and stronger article. All sharp corners should be slightly rounded off. A broad cap, with top curved in section, fixed to the top rail, gives a nice finish.

Chapter VIII.

THINGS FOR THE GARDEN.

A Garden Chair—A Garden Seat—A Folding Table—A Rough Garden Table—Trestle Tables—A Home-made Sundial—A Dog-kennel—A Simple Gate-fastening—A Safety Rack for Garden Tools.

A GARDEN CHAIR.

THIS chair (Fig. 41, *a*) is light and strong, and has a back that can be adjusted to any of several slopes.

Material.—Spruce (white deal), free from splits and other blemishes. Pieces for frame, 2″ × 1″; for arms and back rail, 3″ × 1″; boards for seat, ½-in. wood to finish ⅜ in.; cross strips for back, 1″ × ¼″ laths, or slips cut from a white deal board.

Dimensions.—Width between arms, 18 in.; height of seat at centre, 13½ in.; distance from seat to top of arm, 8 in.; height of back, 2 ft. 2 in.; depth of seat from front edge to the extreme back of the frame, 23 in.; side frames, 20 in. wide at the base outside the legs; 16 in. wide outside under the

arms; 20 in. high to under side of arms; seat rail, 14 in. to upper edge on front leg and 12 in. on back leg.

Construction.—Before cutting-out is commenced, draw the side elevation (Fig. 41, *b*) full size on a sheet of brown paper, in chalk. This will save time and make construction easier.

Begin on the side frames. Lay the brown paper template on the floor, and place the legs of one frame on it, and on them nail the rails, R and R^1, for arm and seat respectively, and the strut, S. The nails should be long enough to be clinched on the inside. Rail R^1 projects 5 in. beyond the front leg, and is bevelled off to continue the lower line of strut S. The second side is made from the first. The front rail, R^2, under the seat is hollowed out on the front edge to a depth of ½ in. at the middle, and nailed to the front of the sides. The back rail, C, 3 in. wide, is nailed in the angle made by the rail, R^1, with the back leg of each side; and the rail, D, also 3 in. wide, to the back of the legs, level with R.

The *seat* is composed of boards not more than ⅜ in. thick, so that they may be curved to fit the front rail, as seen in Fig. 41, *a*. To hold them down in position a 2″ × 1″ rail must be fixed fore-and-aft (Fig. 41, *c*) from the centre of R^2 to C. It is notched into R^2, and screwed to the under side of C. When this is in position the seat boards—the front one

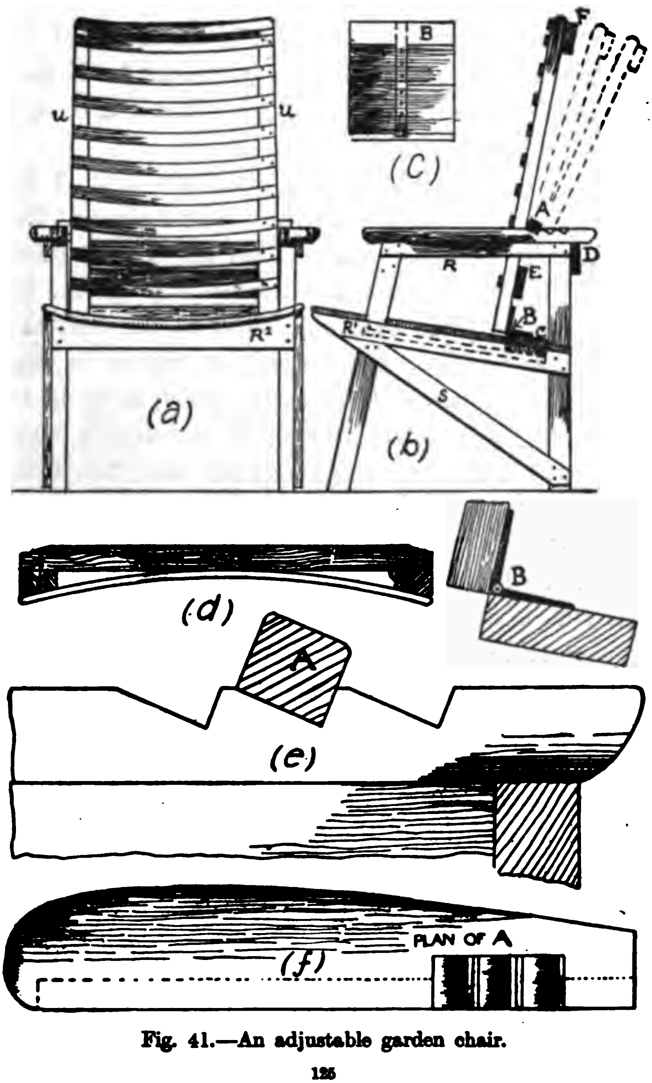

Fig. 41.—An adjustable garden chair.

of which is notched for the arms—are put in position and screwed down to it, to the front rail, R^2, and to the side rails, $R\,R^1$. Work from the centre to the side rails.

The uprights, U U, of the *back* are 2 ft. 3 in. long and ½ in. narrower at the top end than at the bottom, for lightness' sake. They are held together behind by two cross-rails, E and F (Fig. 41, *b*). The ends of these rails are bevelled off, and the front faces of U U are shaped, as shown in Fig. 41, *d*, to the curve of the laths, which have to be nailed on, 1½ in. apart, to support the sitter's back. The laths must be straight-grained and free from knots, and be dipped in water before being bent. Nail on the top and bottom laths first. These touch the back rails, and will serve as gauges for the curves of the others. Allow a little "spare" at each end of the laths, to be removed when nailing is finished. Put a nail in at one end, bend the lath to the curve required, and drive in a nail at the other end; or a temporary batten may be screwed through the top and bottom laths into E and F, parallel to U and U, to hold all the other laths in their proper positions for nailing. When the back is complete, hinge it at B to C with a couple of "back flaps" (Fig. 41, *b*).

The *arms* are of 3″ × 1″ wood, shaped as in Fig. 41, *f*. The edges, except on the inside, are rounded off. Nail the arms to the top of the legs,

R R and D, so that their edges are flush with the inside of the legs.

The *adjustment* for the back is effected by notching the rear part of the arms (Fig. 41, *b*, *e*, and *f*) to take a loose bar, A, 1 in. square in section. This bar is attached at the centre to E by a spiral spring, to prevent it jumping out of place or being lost.

Paint the woodwork. The chair will last longer if all the parts be given a coat *before* being put together.

A GARDEN SEAT.

It has long been the custom to make seats for the garden with branches of trees in what is termed the "rustic" style; but such seats are seldom if ever comfortable, though certainly very difficult pieces of work for an amateur to attempt. Fig. 42, *a*, is an illustration of a strong, serviceable seat, which can be made by any one able to use a hammer and a saw, and upon which one could sit with comfort. It should be 5 ft. long to give room enough for three persons, or 3 ft. 6 in. long to seat two. The seat is 15 in. or 16 in. above the ground, slopes 1 in. towards the back, and is about 18 in. deep from front to back. The arms are about 11 in. above the seat, and the total height of the back is 3 ft. 4 in. For the legs, ordinary 3″ × 2″ deal quartering is heavy enough; the rails under the seat can be of 5-in. floor battens, the seat itself of two 9″ × ¾″ boards, the back of a thinner board,

11 in. in width, and the arms of any piece of ¾-in. stuff. Before the parts are nailed together, the back legs should be shaped as shown in Fig. 42, *b*. This can be done with a saw or a chopper. Then nail the batten, A, across the end faces of the legs with 2-in. nails, not forgetting to bring the ends about 1 in. lower at the back, and follow this by nailing on the front and back battens. The seat should then be cut out to fit the legs, and nailed on.

Pieces of ¾-in. wood 2 in. wide are nailed inside and outside the legs to support the arms, which are made of wood of the same thickness, rounded on the edges, and slightly shaped, as shown in Fig. 42, *c*, and nailed down. It will be noticed that the board at the back is curved by screwing it back into a hollow cut in the leg with a chisel; or, if this be not practicable, a small wedge-shaped piece can be forced in top and bottom behind the board after this has been nailed to the legs in the middle (Fig. 42, *d*). This will give the necessary curve. The board need not be more than ½ in. thick, as the more spring it has the better. White deal is the wood most suitable for it. It should project at least 2 in. beyond the legs.

If this seat is to be made in best style, it should be mortised and tenoned together, or might have "halved" joints; but the above method will yield a strong and durable article. The wood should

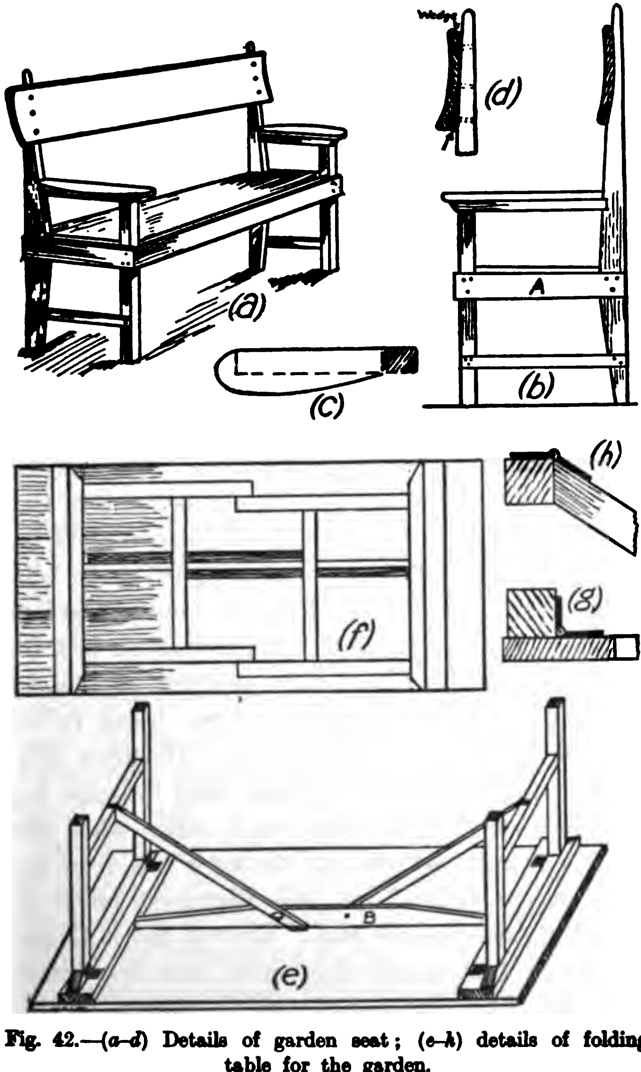

Fig. 42.—(*a–d*) Details of garden seat; (*e–h*) details of folding table for the garden.

be painted. A flat seat and wide back are preferable to a number of spaced-out battens, in that they are more comfortable to the body and do not mark a cushion or the clothes of the sitter.

A GARDEN FOLDING TABLE.

The most useful type of table for a garden is one which will close up into a small space, so that it may be stored away for the winter. Such a table is shown in Fig. 42, *e*, upside down, as this position best illustrates the construction. A handy size for the top would be 3 ft. long and 22 in. wide, and the height about 2 ft. 5 in. The top can be made of two boards of white deal or pine ¾ in. thick and 11 in. wide. They should be screwed or nailed on to 4-in. battens, fixed about 1½ in. from the ends. The legs and rails, of square stuff 2″ × 2″, may either be mortised one into the other, right through, or halved together and nailed, the lower rail being rather more than halfway down the leg. The plan (Fig. 42, *f*) explains how the legs are fixed into the top rail so that they fall into each other when the table is closed. At one side the leg is 1 in. from the edge, at the other 3 in., this alignment being reversed at the opposite end. The top rail is hinged on to the batten with 2-in. iron back-flap hinges (Fig. 42, *g*). Their position is shown on the drawing. Use ½-in. screws. The struts are hinged on to the rail as in Fig. 42, *h*, and fastened to a

2-in. piece, B, under the top with 3-in. thumbscrews, which are easily undone when the table is to be folded up. The thumbscrews can be bought at any ironmonger's. Tables of smaller or larger dimensions may be made in a similar way; or, if the folding-up idea be not adopted, the same construction can be used, except that the top is screwed down on to the legs, and a long central rail, tenoned or halved into the lower end rail, be substituted for the hinged struts.

A ROUGH GARDEN TABLE.

A rough table for general garden use can be made out of the wood of a sound orange or egg box, cut up with a saw and nailed together. The parts of the box are separated carefully, and the best boards selected for the top. The frame should be some inches smaller than the top in both directions; so get the top cut out first, and work from it.

The table shown in Fig. 43, *a*, is 30 in. square and 27 in. high.

To make the legs cut out four pieces about 26 in. long and 5½ in. wide, and slit them down as shown at C, so that each yields two pieces 4 in. wide at one end and 1½ in. wide at the other. The eight pieces are nailed together (Fig. 43, *b*) to form the four legs.

The frame is made by nailing 4-in. pieces to the outside of the legs (Fig. 43, *a*), which should

straddle diagonally about 2½ in. out of the perpendicular. The top pieces can then be fixed on so as to overhang the edge equally all round. Any gaps between the boards should be filled in with putty, and the woodwork be given a coat or two of paint.

If a box is not obtainable, a few rough ½-in. boards could be used instead.

A very handy kind of table for the garden—and, on occasion, for the house—is the well-known trestle-and-board type beloved of caterers. It dates from the time when baronial halls had to be cleared quickly for post-prandial revels, and easy stowage was a necessity. Old specimens may still be seen in some Jacobean houses—notably Penshurst Place, Kent.

Caterers' trestle tables are illustrated by Fig. 43, *e*. The tops, of ½-in. or ¾-in. boards, are either in two parts, hinged together on the under side, as at F, or braced, as shown at G. The trestles are made of 2″ × 1½″ deal. Type H is 2 ft. 5 in. high, 2 ft. wide, and 12 in. between the legs at the base. The legs are notched out so as to fit up against the top piece at the angle which gives the correct straddle. When one leg has been cut out, mark all the others off from it. In fixing the legs, first nail the two to one side of the top, and connect them by a rail; then the other two; and finish by attaching the two end rails.

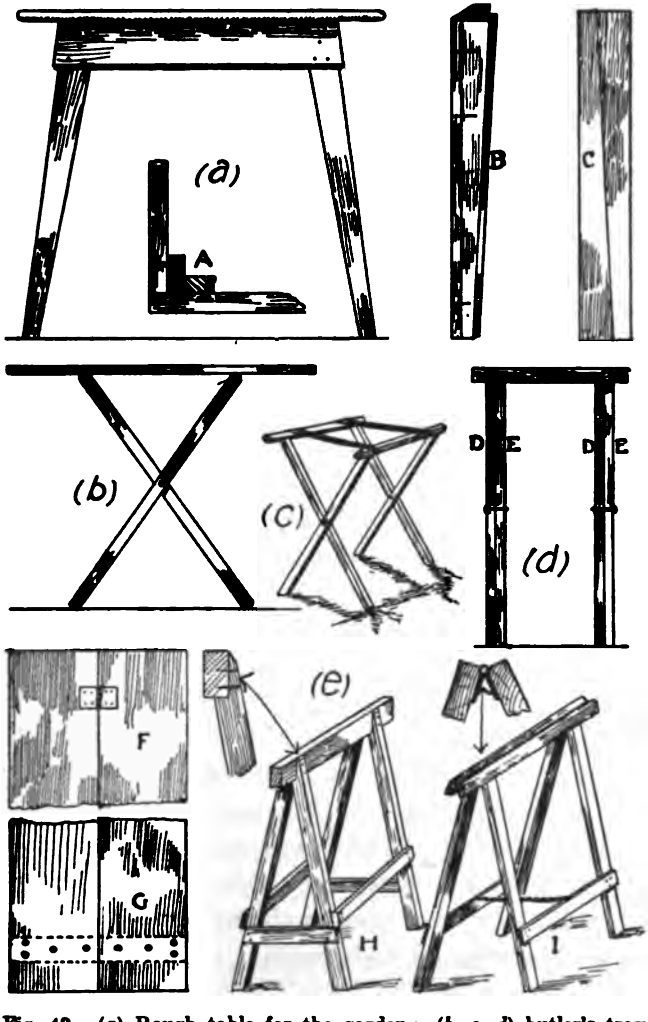

Fig. 43.—(*a*) Rough table for the garden; (*b, c, d*) butler's tray and trestle; (*e*) caterer's trestle table.

Trestle I is rather more difficult to make, but has the great advantage of closing into a small space. The two verticals of each leg are tenoned into a top rail and held together near the bottom by a second rail, nailed on. The frames are hinged together with "back-flaps," as shown in the detail sketch, and prevented from spreading too far by a chain or a piece of cord. The butler's-tray variety is shown in Fig. 43, *b*; the trestle alone, open, in Fig. 43, *c*, and closed in Fig. 43, *d*. Legs and top rails should be of oak, birch, beech, walnut, or other hard wood, 1⅛ in. wide and 1 in. thick. When open, the trestle is usually 2 ft. 9 in. high, and the top rails 20 in. apart. Length of top rails, 20 in.

The legs are tenoned into or through the rails. One pair is set in an inch from the ends of the rail, the other pair somewhat more, so as to fit inside the first when the trestle is closed (Fig. 43, *d*), the legs of each side being pivoted on bolts at the halfway crossing-point. The bolt nuts are inside, for appearance' sake; and the bolts are burred at the ends, to prevent the nuts coming off.

When the trestle has been assembled, the rails are rounded off on the top, and connected by two or three lengths of stout webbing, passed over the top and tacked on underneath.

The top is made by end-clamping together two 11-in. boards of suitable length; or for the clamps may be substituted a vertical framework running

round the edges and provided with handle-holes in the ends.

A HOME-MADE SUNDIAL.

A sundial is an interesting thing to have on a garden wall or the stump of a tree, or to set in a south-facing window. Ordinary flat and vertical sundials require the use of advanced mathematics; but that to be described is within the capacity of any handy person.

One begins by making a cross of thin metal. Brass, copper, zinc are all suitable; copper is the best. The cross may either be cut in one piece out of the sheet, or be compounded of a vertical piece and a cross piece riveted together at the point of crossing. The dimensions given in Fig. 44, *a*, are for a small dial, but they may be modified to suit individual fancy, provided that the circumferential length of the cross-piece B be the same as the distance between the centres of the holes in A.

Mark off the cross-piece into twelve equal parts, and subdivide each of these into quarters or twelfths. The lines may be scratched or etched with acid. For the hours use the Roman numerals, which, being made up of straight lines, are very easily engraved.

When this has been done, bend both pieces to a truly semicircular shape. To get the curve correct one must cut out a cardboard circle with half its circumference equal to the length of the cross-

piece and use it as a template. The exact diameter can best be arrived at experimentally. If copper or brass be used, anneal it by red-heating and plunging into cold water before it is bent.

As the pieces are easily distorted, if of thin metal, it is advisable to solder to the back of each a rib of the same metal, cut out with the aid of the template already made. One rib will have to be severed at the crossing-point to give room to the other rib, to which it should be soldered. If stout strip metal be used, this backing will be unnecessary, but in this case a wooden template had better be cut to the right curve to enable the shaping to be done accurately by hammering.

After shaping, slip a piece of quite straight copper wire through the holes in A, and make them fast with solder.

The dial is now fixed facing the south (in our northern latitudes), with the wire sloping towards the north, and making with the horizontal an angle approximately equal to the latitude of the place—for London, about 51½ degrees. To state the matter otherwise, the axis of the wire should point to the Pole Star. The orientation must be established accurately by a compass.

The dial is most easily fixed by means of a little wooden saddle crossing A, with a screw at each end penetrating either a horizontal base board (as shown) or the face of a wall—in which case the

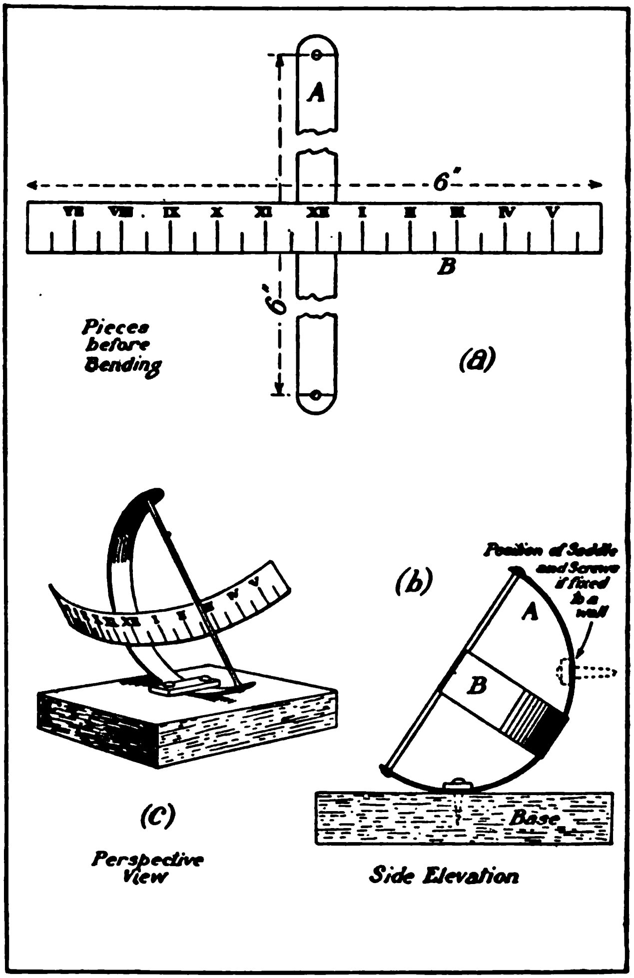

Fig. 44.—A sundial.

saddle would occupy the position indicated by the dotted lines (Fig. 44, *b* and *c*).

When consulting the dial at any time, add or subtract the noon difference for the day from the shadow reading to arrive at clock time. At most the noon difference is only about a quarter of an hour. Consult the early pages of "Whitaker's Almanack" for the allowances to be made.

A DOG-KENNEL.

Two very important points to be kept in mind when designing a dog-kennel are: (1) that the kennel shall be warm and absolutely waterproof; (2) that the construction shall permit the kennel to be easily cleaned out. The kennel shown in Fig. 45, *a*, and described below meets these conditions—the roof projecting to shed water clear of the lower woodwork, and the bottom being separate from the upper part of the structure.

Matched boards are best for sides, ends, and bottom; weather boards for the roof.

The size of the kennel is necessarily governed by that of the dog. Average dimensions may be taken as: length, 30 in.; width, 20 in.; height, 30 in. It is advisable to err on the side of roominess, so that the kennel may be usable by a larger animal than the one for which it is built in the first instance, assuming this to be one of the smaller breeds—fox terrier, cocker spaniel, etc.

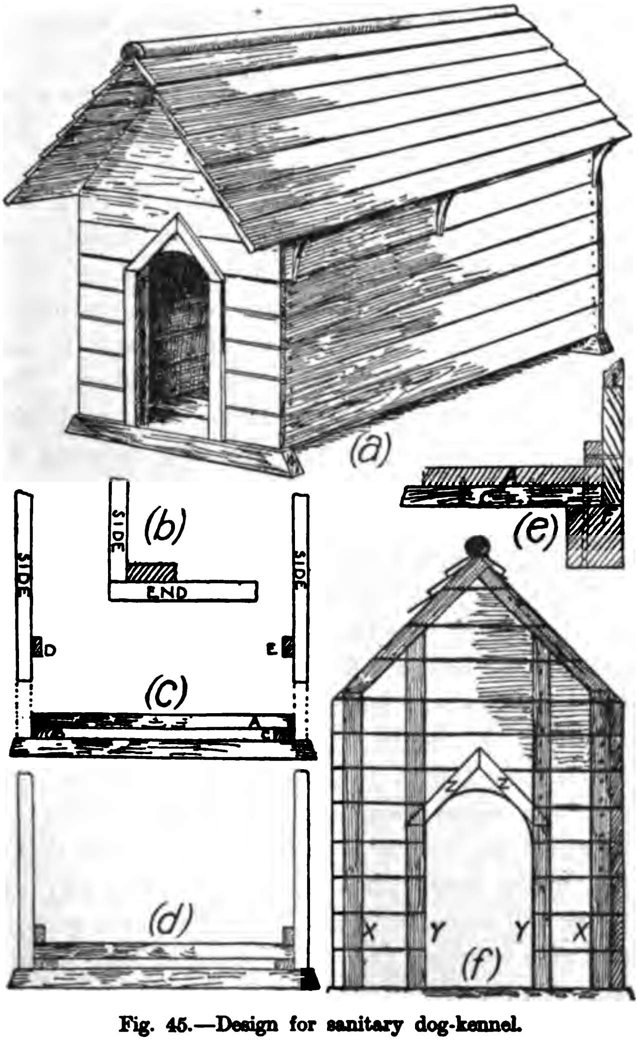

Fig. 45.—Design for sanitary dog-kennel.

The ends are made first by nailing lengths of matching across uprights of 2″ × 1″ batten, as shown in Fig. 45, *f*. At the top the battens are halved or tenoned into the two roof-pieces. The two outer uprights, X X, are set in about ¾ in. from the edges to allow the sides to be flush with the outside of the ends. These four uprights are inside. It is advisable to cut out the door—using a pad-saw for the semicircular top—before nailing on Y Y, which should be a little nearer to one another than are the rough edges of the door. Two short verticals on the outside, also projecting beyond the edges, prevent the dog injuring his coat on them; while the pieces, Z Z, give a neat finish.

The battens, Y Y, may be omitted from the back end of the kennel, but their presence will, of course, strengthen the structure.

When the ends are finished, the horizontal boards for the sides are nailed on to X X at each end (Fig. 45, *b*). Begin at the bottom, arranging the lowest board with tongue pointing upwards, and add the upper boards in order. The direction in which the tongue points is an important detail, for, if the boards are put on the other way up, water will more easily find its way into the grooves and give trouble. (This applies to the ends as well as to the sides.)

Battens D and E (Fig. 45, *c*) are nailed inside

along the sides, and a third across the back, at a distance above the bottom edge equal to the thickness of the bottom boards and of the battens B and C, to which they are attached. Fig. 45, *c*, shows the kennel raised off the bottom; Fig. 45, *d*, the parts in contact; Fig. 45, *e*, a longitudinal vertical section of the back end. At each end a 2″×2″ deal, F, is screwed to B and C to raise the bottom clear of the ground.

The roof weather boards must be long enough to project at least six inches beyond the door end, to prevent rain which falls fairly vertically driving in through the entrance. The eaves overhang three inches, and are supported, as shown in Fig. 45, *a*, by three brackets cut out of hard wood. Begin laying on the boards at the eaves and finish at the ridge, which is closed with a wooden beading or a 6-in. strip of sheet zinc, or zinc outside a beading.

All the exterior surfaces, bottom included, of the kennel should be well tarred or creosoted; the inside limewashed, special attention being given to filling in cracks with the wash.

The inside part of the kennel should be exposed to the sun occasionally, and the bottom be well scrubbed. In short, full advantage should be taken of the accessibility of the interior.

A SIMPLE GATE-FASTENING.

The latch shown in Fig. 46 is suitable for the gates of poultry runs and other similar enclosures.

The catch, A, is a piece of hard wood cut to the shape shown in Fig. 46, *a* ; the latch, C, a flat bar of the same kind of wood. A long slot is cut

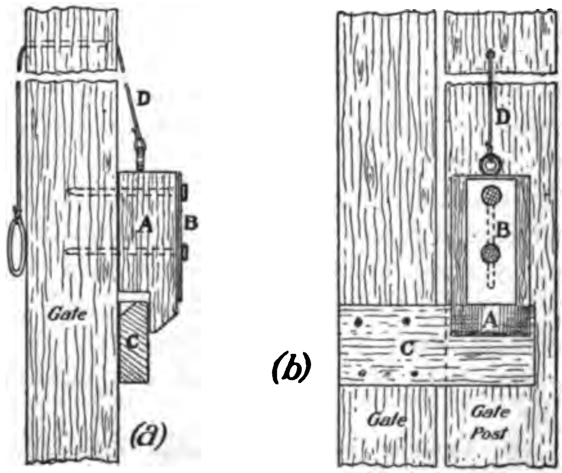

Fig. 46.—A simple gate-fastening.

through A along the centre line to allow it to rise sufficiently on the nails or screws which hold it to the post to give room for C when the gate is closed. A plate of sheet zinc, B, prevents A jamming on the heads of the nails. The catch is lifted by a string, D, passing through a hole in the gate post, and falls back by its own weight. Fix

A in place first, taking care not to drive in the nails, if used, too far, and adjust C to suit. As C acts as gate stop as well as latch, it must be firmly secured to the gate. Bevel off the top back edge to such an angle that it will lift the catch automatically when pushed against it.

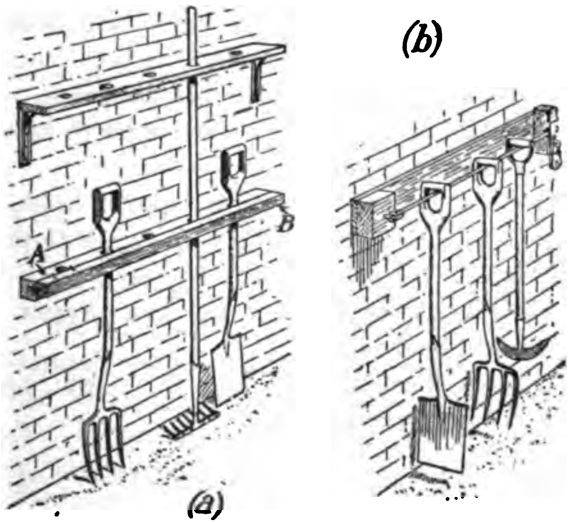

Fig. 47.—Safety racks for garden tools.

SAFETY RACKS FOR GARDEN TOOLS, ETC.

A fastening of this kind, made in half an hour, has been in constant use out of doors for eleven years, and works as well as ever.

The rack shown in Fig. 47, *a*, is intended for holding spades, forks, and other garden tools

which the owner does not wish to be "borrowed." The part A is a 3-in. by 2-in. batten long enough to accommodate the tools when conveniently spaced. This is nailed to the wall, and notched with a pad-saw along the front edge for the handles. The safety bar, B, is attached by strong screw eyes to one end of the rack, and at the other has a hasp which is secured by a staple and padlock. Tools with straight handles, such as hoes, must be stood iron downwards, and will be made more secure by an open rack above the other to prevent their being moved sideways.

Fig. 47, *b*, is a modification for spades, forks, and other tools with open handles, which are threaded on a bar. This arrangement is simpler, but has an obvious disadvantage if the tool nearest the hinging end be required.

The rack illustrated by Fig. 47, *b*, will, on a smaller scale, serve for keys.

Chapter IX.

MORE THINGS FOR THE GARDEN.

A Garden Fountain—A Tank in Reinforced Concrete—A Home-made Garden Roller—A Force Pump for the Water Barrow—A Mole-trap.

A GARDEN FOUNTAIN.

ANY garden, however small, will be improved by the inclusion of a fountain. The trickling of the water is grateful to the ear on a hot summer day, while the jet, by virtue of its continuous movement, attracts the eye.

The following description deals with a fountain worked by an independent tank. Apart from the tank, the instructions will of course apply equally well to one connected directly with a public water supply service. (Fig. 48.)

The fountain is situated in the middle of a grass plot or a suitable corner. For basin one may select a large earthenware vessel—a milk pan or bread pan, for example. A trench two feet deep, for a lead or "compo" pipe of, say, $\frac{3}{8}$ in. internal diameter, is dug from the site of the fountain to the tank or other source of supply.

Two holes are knocked in the bottom of the pan, one for the supply pipe, the other for the overflow pipe. The joints are made watertight by covering the bottom with an even layer of cement an inch or so thick. The pan is then surrounded by a rockery, or bank for flowers, or by some other means of concealment which may suggest itself to the individual's taste.

Into the end of the supply pipe fit a cork, through the centre of which has been burnt a hole to take a ⅛-in. copper tube of such a length as to project some distance above the surface of the water. The nozzle of this is contracted by hammering it round a large pin, which is afterwards extracted; or the end may be flattened, a small opening being left on each side. It is a good idea to have several spare tubes with orifices of different sizes.

The lead pipe should be in one unjointed piece long enough to reach the tank or tap. The exact length is decided by careful measurement before ordering.

The tank, if one be used, may be of wood, carefully put together, putty being used to make the joints quite watertight. (Allow the putty to get well set before the tank is filled.) The tank should be fixed at least six feet above the level of the fountain, on the side or top of a wall, or in a tree, or on an independent support made specially for the purpose. In any case the tank should be kept

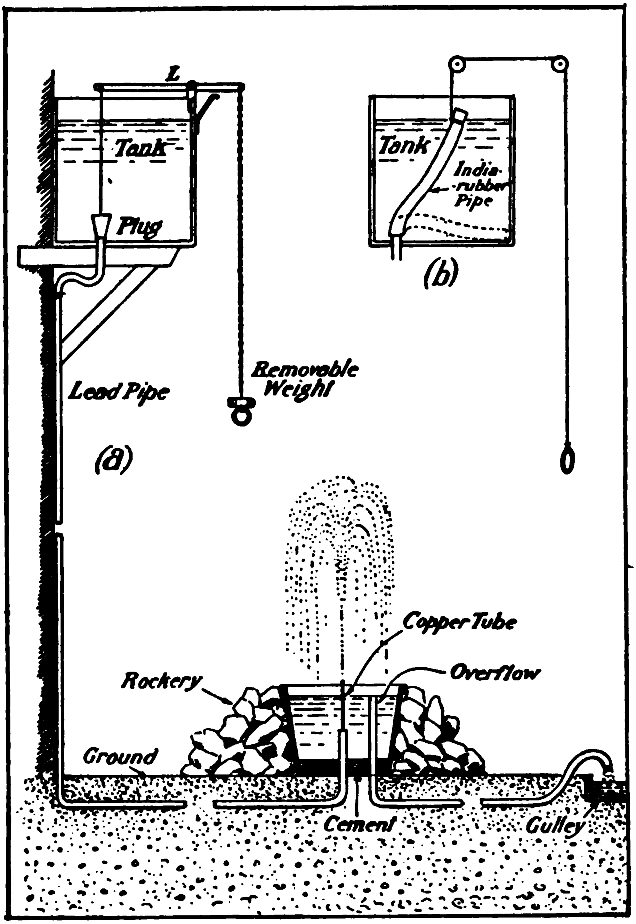

Fig. 48.—Details of garden fountain.

out of sight, so as not to dispel the "mystery" which properly belongs to a fountain. Other points to observe are, that a wooden tank must be kept full to prevent shrinkage, and that its position be convenient for filling. If a gutter be led into it —and this has an obvious advantage—the water

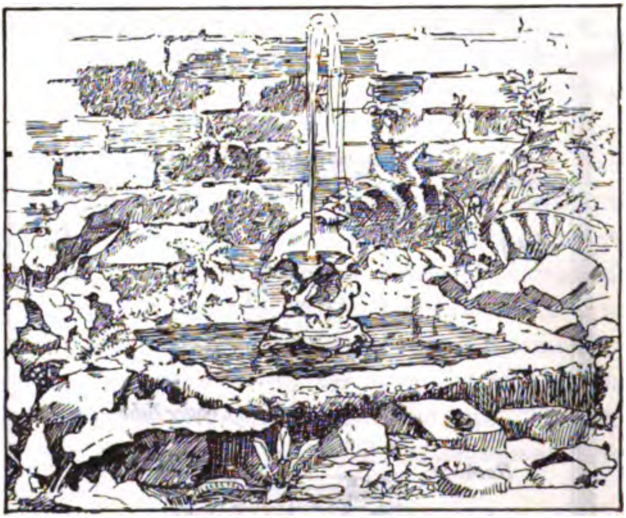

Fig. 49.—Fountain made out of old earthenware sink, covered over with cement and rockwork.

should pass through a strainer, as otherwise the pipe and jet would soon be blocked by rubbish. For the same reason keep the tank well covered.

The regulation of the water may be effected in several ways. (1.) A straight tap is driven into a hole in the bottom of the tank, and the pipe forced

inside or outside this, the joint between the two being made watertight either by soldering or wrapping round with rubber strip. (2.) The pipe is pushed an inch or so through a well-fitting hole —the wood, by swelling, will prevent leakage— and to the top is fixed a piece of rubber tubing as long as the tank is deep. The free end of this is raised or lowered by a string, as shown in Fig. 48, *b*, to cut off or turn on the water. (3.) The top of the pipe is expanded to fit a conical wooden plug, weighted so that it shall not tend to float (Fig. 48, *a*). This is attached by a wire to a lever, L, which can be pulled down sufficiently to raise the plug almost out of the pipe.

As an alternative to a pipe overflow, as shown in Fig. 48, *a*, one may make a notch in the lip of the basin, and allow the escaping water to flow down in a tiny fall among ferns and other water-loving plants. From the bottom of the fall a channel or pipe should run to a ditch or gulley.

A TANK IN REINFORCED CONCRETE.

Reinforced concrete, or ferro-concrete, is now widely used, and can so easily be put to many useful purposes that the amateur may well avail himself of its advantages on a small scale.

It consists of ordinary concrete—Portland cement, sand, and stones, or some similar material—with iron or steel bars or rods so distributed among it

that the concrete takes the compressional, and the metal the tensional stresses. Thus in a horizontal beam supported at the ends, the reinforcement would be near the bottom; in a pillar, near the outside. Each component is in this way assigned work for which it is best fitted, and the result is an extremely strong, durable, and reasonably light form of construction.

Materials.—The amateur, who is concerned mainly with small work, will find stout wire-netting or straight-woven wires very suitable reinforcement for the articles he makes.

For the concrete one needs some good Portland cement, which should be purchased from a builder; some good sharp sand; and a supply of granite chippings, such as are used for garden paths, or, failing these, small gravel, or even broken brick or coke. The size of the pieces must to a certain extent depend on the nature of the work, as it is important that the largest pieces should be well embedded.

Mixing the Concrete.—In mixing, the principle to be observed is that the sand should fill the larger spaces between the stones, etc., and the cement the smaller spaces into which the sand cannot penetrate, so as to produce a solid mass in which every stone or grain of sand is coated with cement and there is no space left unfilled. To ascertain the proportions, mix measured sand in with the stones

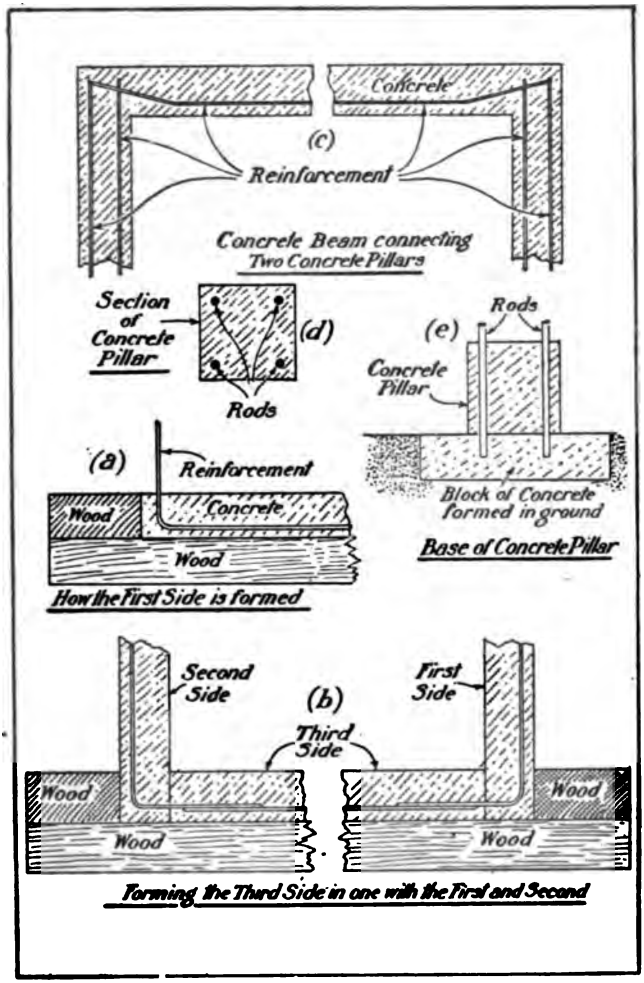

Fig. 50.—Reinforced concrete work.

until no more can be added without hiding the top stones; and then add measured water till it stands level with the top of the mixture. The volume of the water is the volume of the cement needed for that particular bulk of stones and sand. Speaking generally, the proportions are: Stones, etc., four parts (by measure); sand, two parts; cement, one and a quarter parts. If great strength be needed, the cement and sand should be used in equal quantities.

Thorough mixing is of the first importance. "Thrice dry and twice wet" is a good rule—turn the whole mass over three times while in its dry state, and twice after the water has been added. Pour the water from the rose of a garden can, and stir the stuff well as the water is added. Every particle must be wet; but there should be no superfluous water, which will merely carry off a lot of the cement with it.

Making the Tank.—Reinforced concrete, being quite unaffected by damp, and imperishable, is an excellent material for tanks to catch rain water. Construction will be simplified if the tank be cubical—four sides and bottom square and of the same size. A tank 2 ft. cube inside holds 50 gallons; 2 ft. 6 in., 95 gallons; 3 ft., 170 gallons. We will assume that a 50-gallon tank is projected.

Begin operations by making a tray of boards

with a rim 1¼ in. high enclosing a 2 ft. 3 in. square. This is the mould. After greasing the inside, pour enough ballast into the tray to fill it about level with the top of the rim; empty out, and mix this with a proper quantity of sand and cement. Spread a ⅜-inch layer of concrete over the bottom of the tray with a bricklayer's trowel—cost, 1s.—and lay on it a piece of wire-netting wide and long enough to cover the concrete and turn up three inches along three of the edges. Then fill the mould with concrete, smoothing off the top with a straight-edge (Fig. 50, *a*). Leave it for two days, and then stand the slab on edge in a damp corner to set thoroughly. Meanwhile a second slab is made in precisely the same way, and in turn is stood up to set.

The two slabs are then stood on edge in the mould, at right angles to it and parallel to one another, and fixed firmly in position. Proceed as before, twisting or tying the netting of the third side to that of the other two before covering it with concrete (Fig. 50, *b*).

When the new slab is ready, turn the combination over carefully so that the free edges of the first two slabs rest in the mould, and add the fourth side to them. It then only remains to give the tank a bottom. If this is to rest on the ground, it need not be reinforced. Clear a little space 2¼ feet square, and excavate it to a depth, say,

of three inches. Fill up with concrete of a rough sort, plenty of big stones being included. Level the upper surface with a straight-edge.

Give the foundation a little time to set, and stand the four sides already finished upon it. Then spread an inch-thick layer of fine concrete on the bottom. The projecting edges of wire-netting along the bottom will of course ensure a good strong joint between the sides and the bottom. Finally, damp the inside of the tank and face it with pure cement mortar, spread on thinly with a trowel, to fill up all hollows and make the concrete quite watertight.

Should you wish to raise the tank up a foot or so, you must build two oblong blocks of concrete or dwarf walls, one to be under each of two sides. To ensure that neither shall sink afterwards, carry them down into the ground six inches or so by digging a trench and filling it with concrete, carefully ramming the bottom of the trench before filling. The parts of the wall above ground are formed in moulds made by nailing some boards roughly together. When the concrete is set, remove the boards.

The bottom in this case should be reinforced like the sides. Cut a piece of wood which will just go in between the concrete blocks. Place the sides on the blocks, push the board under and pack it up underneath. Then make the bottom in the same way as the sides.

Pillars.—Vertical members, such as pillars and struts, are easily formed in boxes, say, three inches square, with a reinforcement of ¼-in. iron rod near each corner (Fig. 50, *d*). Start by making a block of concrete in a hole in the ground as a base (Fig. 50, *e*). Let into this, as you make it, the ends of four rods, two inches apart. Then place round these a tall box made by nailing four planks together, tying the tops of the rods together with wood between them, so that they are just about the right distance apart all the way up. Drop the concrete carefully in at the top of the box. The fall alone will help to solidify it, but there should be some ramming with a stick.

Should you wish to raise the tank, say, five feet above the ground, when you have carried up the four pillars to about five feet, make four wooden troughs, three inches square inside in section, and fix these so as to connect the unfinished ends of the uprights. Lay three rods in the bottom of each over a thin layer of concrete and fill up. The horizontal rods need not be actually connected to the upright rods, but should pass near them. The concrete will form a very strong connection between the two.

Theoretically the horizontal rods should slope up a little at the ends, as shown in Fig. 50, *c*.

The four beams thus connecting the pillars make a stage on which the tank may be placed. If the

tank be higher than five feet, put extra horizontal beams halfway up.

It is of the greatest importance that the iron rods should be well covered with concrete, as otherwise they will corrode in course of time; though, if properly covered, the metal will endure for ever.

The experimenter may pass from so simple a thing as a tank to more complicated objects, such as kennels, fowlhouses, large flower "tubs," and many other things which may suggest themselves to any one who has become interested in this kind of work.

A HOME-MADE GARDEN ROLLER.

If there be lawns and gravel paths in your garden, but no roller, or if there be a roller and that only a very light one, it will be worth your while to try your hand at making the article described below. The roller itself is a cylinder of concrete cast round an iron bar which acts as axle. Assuming it to be 18 inches long, it will weigh about 2 cwt. if 15 inches, and about 3 cwt. if 18 inches in diameter.

The most difficult part of the business is to prepare the mould in which to cast the cylinder. It is impracticable to make a truly cylindrical one of wood, so we must content ourselves with a wooden casing filled in with plaster of Paris to the desired shape.

If the smaller size of roller be contemplated, knock up a box 18 inches long, the sides being held

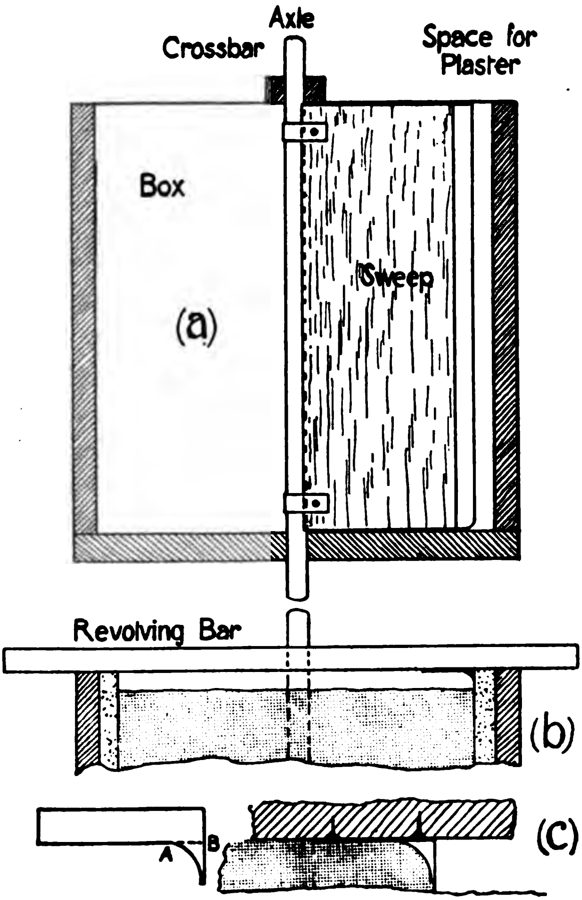

Fig. 51.—Box for casting home-made roller.

together by pieces in the corners. This is stood vertically on an end plate, which should be smooth inside and as flat as possible. The top of the box is open.

In the centre of the bottom bore a hole into which the axle, a piece of ¾ or ⅞-in. steel bar, 2 ft. long, will fit tightly. Adjust the bottom until the hole is equidistant from the centres of all four sides, and nail or screw it on to the sides. Then prepare a crossbar 2 in. wide, with a hole of similar size to the other, and adjust the hole in the same way, tacking the crossbar to two of the sides with wire nails.

Now prepare the "sweep," with which to shape the plaster lining. This is a board 1 in. thick, 18 in. long, and 6 in. wide. Hollow one long edge slightly with a gouge to fit the axle. Along the other nail a strip of thin metal to one side of the board so that it projects sufficiently to make the total width of the sweep 7½ in. *less* half the diameter of the axle. Apply the hollowed edge to the axle and secure it by two light metal straps passing round the latter, one near each end of the board (Fig. 51). The bottom corner is rounded to a radius of ¾ inch.

Pass the axle through the top bar, the two straps, and the bottom of the box, and revolve it. If it jams in any one position, the axle is not quite square to the bottom, and some adjustment of the bar will be necessary.

Using the sweep as a guide, fill in the corners of the box with odd pieces of wood arranged vertically and tacked together until a free space ½ in. to ¾ in. is left all round between them and the sweep; and drive in a number of tacks with their heads projecting about ¼ inch to act as keys for the plaster.

The cast is prepared by dropping the dry material into a pan containing some water, working it until all lumps are broken up and the whole mass is plastic, but stiff enough to "stand on its own legs." Do not mix too much at a time, lest it should harden before it can be used. Coat the inside of the mould in layers by hand, again using the sweep as a guide, and smooth off the last layer with the edge of the sweep.

Casting the Cylinder.—Leave the mould to harden for twenty-four hours. Then clear away any projections and roughness, and grease the inside of the bottom and wall of the mould thoroughly with vaseline to render it waterproof. Arrange the axle so that it projects an equal distance through the bottom and the top bar, and wedge it in position.

For the cylinder is required a couple of bucketfuls of fine concrete of the kind described on page 152, and a number of large clean stones or brickbats (which should be well soaked in water) to act as displacers and save concrete. Put in a layer of concrete an inch deep, pugging it well to bring the cement against the faces. Then arrange

a layer of stones, etc., keeping them ½ in. away from the outside, and add more fine concrete till all are covered, working it into crevices. Keep repeating the process until the mould is filled to within one inch of the top.

Allow the concrete to set for a few hours and then remove the top bar. A special "former" is required to round off the upper end of the roller. Cut out a piece of stout tin to the shape shown in Fig. 51, *c*, bend it at right angles along the line A B, and nail the piece to the under side of a flat bar 20 in. long with a hole at the centre to fit the axle. The vertical edge of the piece must be arranged to just touch the inside of the mould (Fig. 51, *b*).

Now wet the upper surface of the cylinder and mix some concrete rather dry and fill in the space, beginning at the circumference and forming a ring, shaped by the striker, as you go round. The interior is then brought up flush with the top of the box.

The casting should be allowed to harden for a week or two—the longer the better, in fact—before it is removed from the mould. For the first few days keep the top of it damped with water, and covered up with a wet sack.

The Handle.—During the hardening period the handle can be made. This is a simple affair of wood, and as it is light it need not be counter-

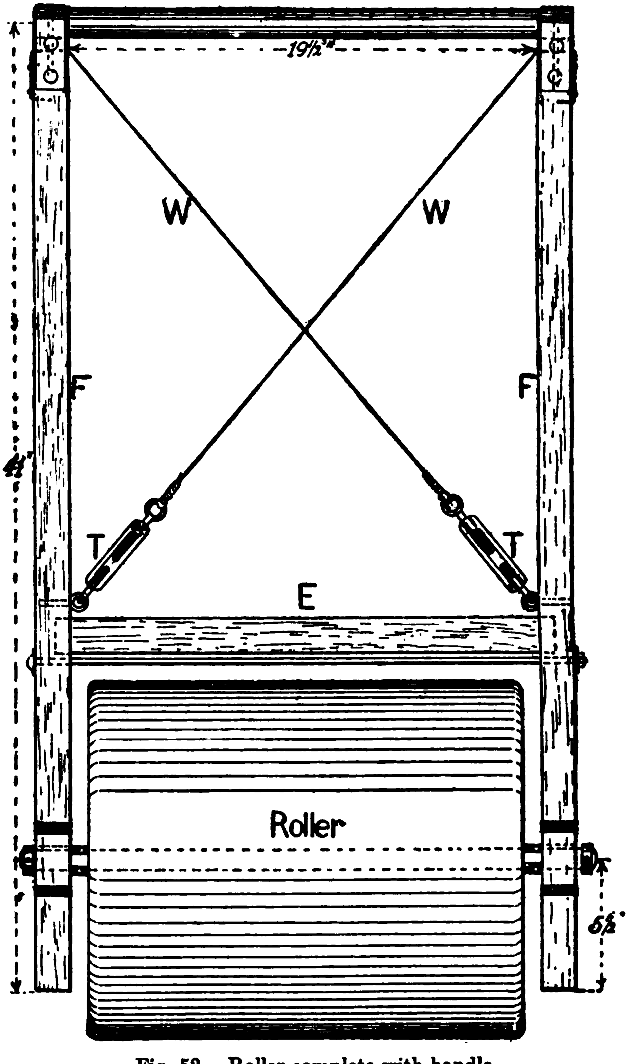

Fig. 52.—Roller complete with handle.

balanced. A plan of it with dimensions is given in Fig. 52. The side pieces F F and crossbar E are 2½ × 1½ in.; the handle a piece of 1¼-in. round rod. F F are tapered off vertically beyond the crossbar till reduced at the handle end to 1¼ × 1¼ in. E is stub-tenoned into F F—that is, the tenon extends only part way through—and is held in place by a ¼-in. rod with nut and washer at each end. This last can be purchased for a small sum at any ironmonger's. The small ends of F F are hollowed to fit the handle, which is secured by iron pegs projecting 3 in. into the sides, and by thin metal straps. To prevent the frame being deformed, two cross bracings of $\frac{3}{32}$-in. *galvanized* wire are provided. Each bracing must include a right and left-hand turn-buckle, T, by which to tighten and adjust the wires, which are secured by being passed through the sides, turned over at the ends, and driven home, a few staples making everything quite safe.

Metal bushes must be interposed between the axle and the sides. For this purpose two 1½-in. pieces of stout brass (preferably) or iron tubing fitting the axle closely but easily will suffice. The holes in the sides for these need careful boring, for if they are not quite square the bushes will not be in line and the axle will tend to jam. The holes should be a tight fit, and to prevent splitting wrap the sides with wire on both sides of the

hole before driving the bushes in. An alternative to the bushes is to bore holes in the sides rather larger than the axle and to screw on to the inside faces the small plates of ¼-in. iron, with holes to fit the axle. After the handle has been put in position on the roller, similar plates are screwed on the outside faces. To make a neat job both sets should be countersunk into the wood.

Four collars of tubing are needed, two ¾ in. wide (or ½ in. if non-countersunk plates are used), to interpose between handle and cylinder, and two ⅜ in. wide, to fix to the axle outside the handle.

To return to the cylinder itself. When this has hardened sufficiently (as will be determined by testing the top end with a metal instrument) break away one side of the casing and mould and extract it. Any holes in the surface should be filled in with fine cement, and the upper end be finished off neatly with the trowel. Now assemble the handle on the roller, taking care to put the spacing collars between it and the cylinder, and mark the positions of the outside collars. Remove the handle and drill holes through the outside collars and axle for split pins. Then reassemble and give the handle a couple of good coatings of paint. It is inadvisable to use the roller on paths till it has matured for three or more months. This is an argument in favour of making it in the autumn and letting it stand idle until the spring.

A FORCE PUMP FOR THE WATER BARROW.

The pump described below is intended for attachment to the inside of an ordinary garden water barrow. It will be found useful for spraying on a large scale, and for watering generally. The air chamber is large proportionately to the pump, to prevent the delivery being at all jerky.

Dimensions.—The pump has a bore of 2 in. and a stroke of 3 in., and delivers about 9 cubic in. ($\frac{1}{32}$ gallon) at every stroke. The air chamber is 5 in. high and 3 in. in diameter outside.

These parts are attached to a bedplate of brass or of stout zinc, which in turn is secured to a base of oak, 8¼ in. by 5 in., the last being screwed to a back-piece of similar wood (Fig. 53), 8¼ in. by 8 in. by ¾ in., and further held to it by a stout stay at each end.

The Pump.—This, the air chamber, and base plate should be made first.

The pump barrel is a piece of stout solid-drawn brass or copper tube 4½ in. long. The ends—especially the bottom—should be lathed off, or filed as true as possible. This done, procure a stout brass disc, 3 in. in diameter, mark the centre, and from it describe a circle of the same size as the external diameter of the barrel. A second circle of ¼ in. greater radius is scribed, and divided into six equal parts by radial lines.

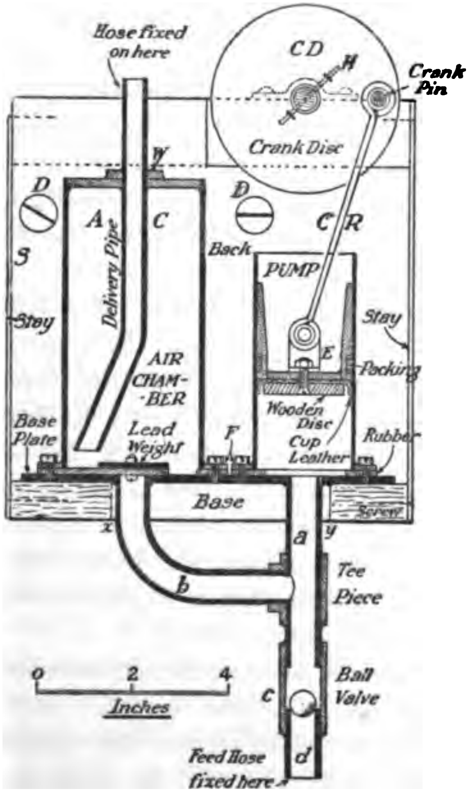

Fig. 53.—Force pump and air chamber and valves in section, on stand.

Make punch marks at the points of intersection. The central part is then cut out, leaving a ring which should fit the barrel tightly.

The piston may be built up out of a piece of stout brass tube fitting the barrel closely, and a washer

turned to fill the bottom. The outside of the piston has a groove $\frac{3}{8}$ in. wide and $\frac{1}{8}$ in. deep for packing turned in it near the bottom. If a lathe be not available, the making of the piston might well be entrusted to a professional, who would not charge more than a few shillings for doing the job. A hole for a $\frac{3}{16}$-in. screw must be bored in the bottom.

The gudgeon E is made out of stout brass strip $\frac{3}{4}$ in. wide and $\frac{1}{16}$ in. thick. The centre of the gudgeon pin hole is $\frac{3}{4}$ in. from the top of the piston. The gudgeon, and a cup leather and a wooden disc under the piston (see Fig. 54), are held together by a single central screw and nut. The use of a cup leather makes it impossible for any water to escape past the piston during the down stroke; the packing is to prevent air entering during the suction stroke.

If saving of cost be important, a boxwood piston will serve, though of course it cannot be expected to last so long as one of metal. Any turner would make one for a few pence. Its walls should be as thick as is possible without interfering with the swinging movements of the connecting rod.

The gudgeon pin could in this case be passed through the piston itself, the part E being dispensed with; but its ends should be carefully rounded off to prevent any scoring of the inside of the barrel.

Air Chamber.—The top end is filled with a brass disc bored centrally to take the delivery pipe. The last should have a bore of ⅜ in., be of stout metal, and be bent towards the bottom as shown, so as not to foul the valve. The washer, W, is to stiffen the pipe. The holes in this and the top should fit the pipe tightly, and the top be a driving fit with the barrel. Solder top to barrel by heating and running solder round the inside angle; then turn the chamber right way up and sweat the pipe and W in while the metal is hot. A flange, 4 in. in diameter, is prepared and marked for six screws in the manner already described.

Bedplate.—This should be preferably of brass, ⅛ in. thick, and measure 8¼ in. by 4¼ in. Perfect flatness is important.

The flanges of the pump and air chamber are arranged on it, with their centres situated as shown in Fig. 55, wherein the heavily dotted longitudinal line corresponds to the nearer side of the wooden back. Scribe round the flanges and clamp each in turn in position on the bedplate, while a hole is drilled through flange and plate with a drill of the proper tapping size for a $\frac{3}{16}$-in. screw. Then separate the parts (after making matching marks), and ream out the hole in the flange to pass the screw. The flange is then screwed on while the other five holes are drilled, those in the plate being subsequently tapped, and those in the flange

reamed. This method ensures the holes pairing exactly.

The flanges may then be driven on to the barrels —which should project about $\frac{1}{16}$ in. to get a better hold of the rubber packing—and soldered securely.

Drill and countersink a hole near each corner and halfway along each long side for screws to hold the bedplate to the base.

The Valves.—The general arrangement of the valves and connections is shown clearly in Fig. 53. The pipes *a*, *b*, and *c* are copper of ½-in. bore.

Pipe *b* is connected to *a* by a tee-piece soldered to both, a hole being cut in *a* where *b* meets it. Both are soldered to the bedplate. The inlet valve chamber, *c*, is a piece of larger pipe soldered to *a* and the nozzle, *d*, for the feed hose. A gun-metal ball acts at valve. The seating for it in *d* is prepared by hammering in a steel ball of the same diameter. Run a pin through *c* to prevent the ball lifting more than ⅛ in. from the seat.

The delivery valve is integral with the rubber washer between air chamber and bedplate—a circular piece connected with the ring by a wide tongue. To ensure the valve closing promptly, a disc of lead is bolted to its upper side, as shown.

The Stand.—The *base* has a slot cut in it, as indicated in Fig. 55, to allow the pump to be removed. The *back*, C, has a ledge, B, screwed to

the face next the barrow, and a piece, A, similarly attached on the other side. Fix the base to C

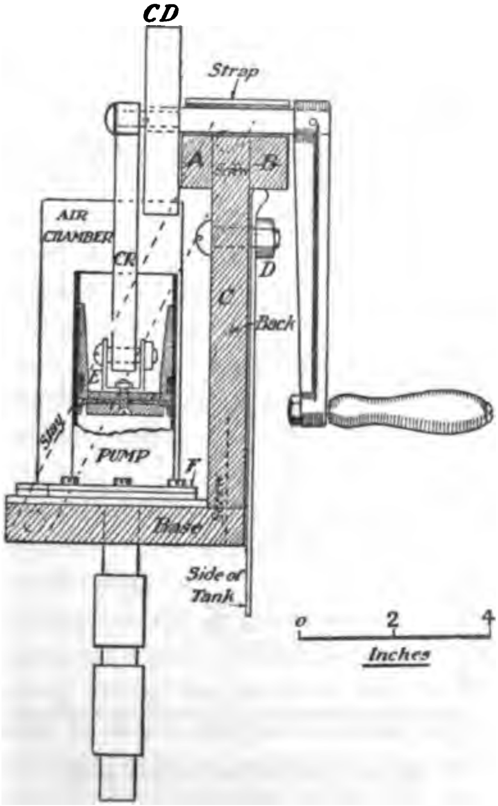

Fig. 54.—Side view of force pump.

by three long screws. Grease all screws and paint all contact faces before assembling, to keep out water. Screw holes should be drilled to full depth.

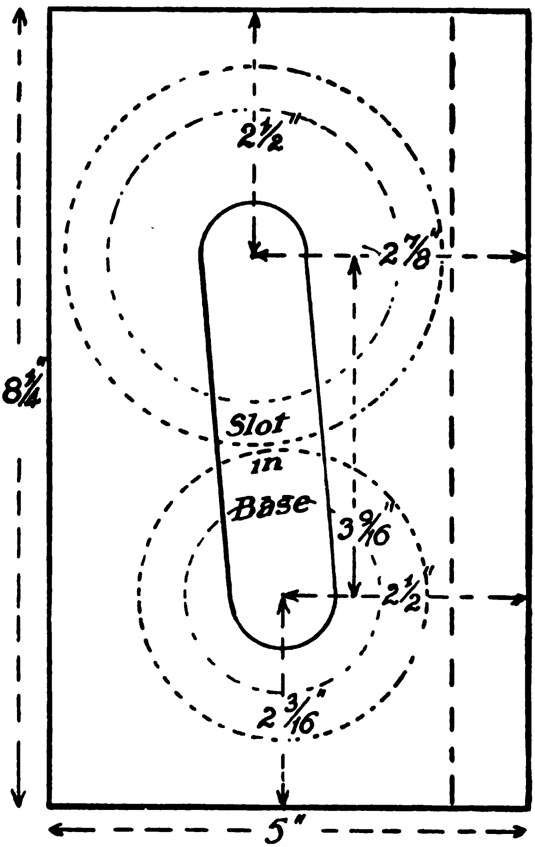

Fig. 55.—Plan of base of force pump.

The grain of the base runs from back to front; of the back, horizontally. The stays are of $\frac{1}{2}$-in. by $\frac{1}{8}$-in. iron strip.

Crank, etc.—The crank axle is a 4-in. length

of ½-in. steel bar. Near one end drill a $\frac{3}{16}$-in. hole. For the bearing procure a 2¼-in. length of brass tubing which fits the rod tightly. The crank is a disc of oak 4 in. across, bored centrally to make a driving fit on the axle. Sink in the outer face a notch $\frac{3}{16}$ in. wide and deep to take a pin, H, passing through the rod. This pin, held firmly to the disc by a couple of staples, prevents the crank shaft turning in the disc.

The tube is bedded to half its depth in a notch filed across A, B, and C on a line perpendicular to the back and passing over the centre of the pump, and is held down to the back by a metal strap, screwed at three points on each edge. Drill a central lubricating hole through the strap and tube.

The crank pin is a ¼-in. round-headed carpenter's screw, driven tightly into the boss 1½ in. from the centre.

The *connecting rod* is brass or iron strip ½ in. wide, bent round and soldered to pieces of brass or iron tubing fitting the gudgeon and crank pins. Care must be taken to get its length correct. It may be found easier to make it in two parts, soldered and screwed together when the pump has been fixed in place. This method will ensure the length being accurate, and, by doubling the metal at the centre, give strength to the rod where it is most required.

A handle of the type shown, with a 6-in. "throw," can be purchased for a small sum. It should fit the shaft closely and be attached by a tapered pin.

Assembling.—Cover the woodwork and stays all over with two coats of good paint.

For the packings and discharge valve use rubber-and-canvas sheeting $\frac{1}{8}$ in. thick. This can be obtained cheaply from any dealer in rubber goods. Cut with a sharp, moistened knife. Screw holes are made with a leather punch.

After screwing the pump and air chamber to the bedplate, screw the bedplate to the base. Fix one end of the connecting rod to the gudgeon, and then screw the gudgeon to the piston, interposing the cup leather and wooden disc. The crank is then slipped into place, the handle attached, and the upper end of the connecting rod screwed to the crank disc. If the rod have been made in one piece, and the piston "bottoms" in the pump, a fresh hole should be made for the crank pin, rather nearer the centre. If, however, the rod be in two parts, bring them together, turn the crank into its lowest position, draw the piston just clear of the bottom, and mark the parts preparatory to screwing and then soldering them.

The only thing remaining to be done is to bore two $\frac{3}{8}$-in. holes through the back and the water barrow to take the bolts D D (Fig. 54).

A MOLE-TRAP.

A trap much used by country folk for snaring moles is sketched in Fig. 56. It is very easily made, and serves its purpose at least as well as the steel traps sold in the shops, possibly better, as the woodwork, if allowed to get clayey, arouses less suspicion in the mind of Mr. Mole than does metal. The materials required are a piece of $\frac{1}{4}$-in. wood, P, 5 in. by 3 in., one foot of $\frac{3}{8}$-in. cane, and a springy stick of some kind.

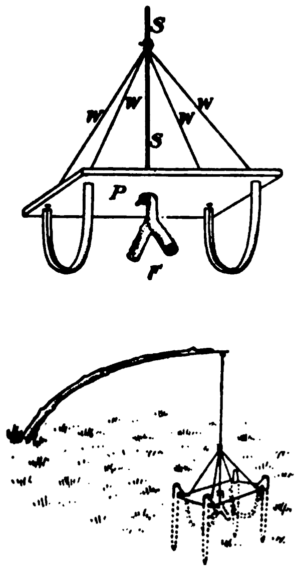

Fig. 56.—Home-made mole-trap.

Split the cane down the centre and sharpen the ends to a blunt point. Then bore a $\frac{1}{4}$-in. hole near each corner of P, and force the ends of a piece of cane into each pair of holes to form an arch at each end. In the centre of the board is bored a $\frac{1}{4}$-in. hole to take the sharpened end of a wooden fork, F, cut out of the hedge.

Just inside the cane holes, bore fine holes to take the wire loops, W W. The upper ends of the

loops are attached to string s, which is continued downwards beyond the point of junction just far enough to pass through the plate when the loops of wire are drawn down into the canes. Tie a small knot in the end of s, to enable the sharpened end of the fork to hold the string when pushed loosely into the hole.

Four "crotches" or hooks are required to hold the trap down in the ground, and a resilient stick to act as spring. A hole for the trap is prepared in the run, and the stick is driven at an angle into the ground so that its end when bent down comes over the hole. Attach the upper end of s—which should be looped—to the stick, set the trap, arranging the wires in the cane loops, and turning F so that its arms lie across the run, and peg the trap down in position, taking care not to shake it while doing so. During this operation it is best to wear gloves that have been rubbed on the earth, so that the trap may not suggest the human hand to the mole's very discriminating nose. When the mole arrives and tries to force his way past the fork he will probably dislodge it, thereby releasing the string and wires, and putting a speedy end to his depredations.

Chapter X.

THINGS FOR THE WORKSHOP.

A Home Mechanic's Work Table—A Rough Cabinet for Tools—A Tool Case—A Handy Portable Tool Box—A Tool Rack—How to make a Polishing Machine—Soldering—Casting in Lead.

A HOME MECHANIC'S WORK TABLE.

THE first requirement of any one who seeks to do mechanical work at home is a suitable table. The one about to be described is quite small and compact, so that it can stand in a corner out of the way; which makes it specially suitable for those who cannot devote a whole room to their hobby.

The basis of it is a "scullery" table, which can be purchased at a second-hand furniture shop. The first thing to do to it is to brace the legs with diagonal struts as shown in the sketch, Fig. 57. These struts, made of strips of wood securely screwed to the legs, will convert a somewhat shaky table into a very rigid and steady one. The table should be fixed to the floor by four iron shelf brackets.

Half-way along each end and all along the back erect a wooden wall, with a small shelf on the inner side. Place a raised edge along this shelf, and also divide it transversely with strips of wood into a number of little compartments, which are specially

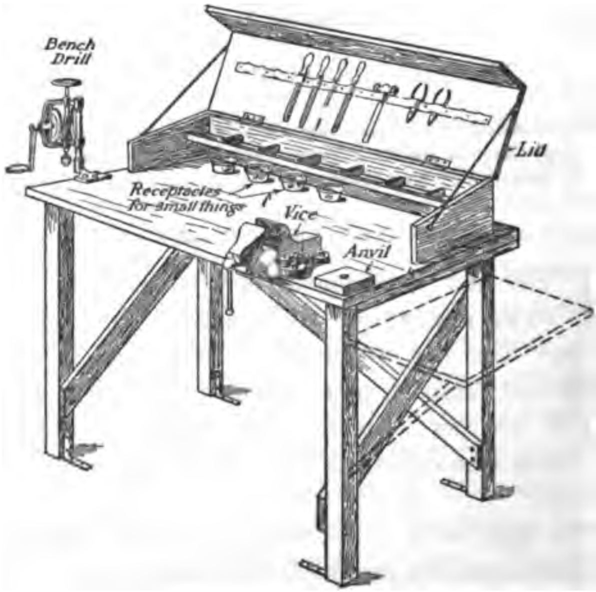

Fig. 57.—The home mechanic's work table.

useful for holding small parts such as are very apt to get lost among the tools and litter which always accumulate upon a workbench.

At the left-hand end of the table it is well to have a hand drilling-machine. One costing about 9s. or 10s. will drill all the holes needed in small

model work. If you own a lathe, this drilling-machine is not necessary, although even then it is useful.

One of the first jobs you do with it is to drill a hole in the centre of a piece of iron to form a little anvil or hammering block, which should be fixed at the right-hand front corner, exactly over the leg. If you have access to an ironworks, you will find plenty of pieces on the "scrap-heap" which would serve admirably as a block. One about 1 in. thick and 4 in. square will be of a convenient size.

But the most important tool of all is a small bench vice, which should be placed just to the left of the anvil. Admirable little vices of a suitable kind can be bought for 5s., or even less, second-hand.

A "flap" shelf, which can be put up or let down at will, is very useful on the right-hand end of the table. It is shown in dotted lines in the sketch, and should be hinged to the upper part of the legs, its outer edge being supported, when in use, by two wood strips hinged to it and having their lower ends in sockets cut in the legs. Since you will find yourself putting your tools on this as you finish with them, you should be careful to fit it up strongly to support a considerable weight.

The table is quite complete as already described, but you may feel inclined to make a cover for it

as indicated. This, when let down, converts the rear part of the table into a cabinet which will house a lot of small tools, half-finished work, and so on. Tapes nailed to the under side of the lid will be very handy for holding small tools such as pliers, files, broaches, etc.

Here is a wrinkle: Obtain a dozen or so of the small glass pots in which condensed meats and preserves are packed, to hold screws, nails, small bolts, etc. As the contents of each can be seen through the glass, the particular one required can be picked out at a glance. These pots can stand in a row beneath the shelf.

A ROUGH CABINET FOR TOOLS, ETC.

Procure half a dozen soap or sweet boxes of the same size, remove the lids carefully, and put some additional nails in the sides and bottoms. Glue pieces of ½-in. wood in the corners and drive brads into these through the outside, so that the trays shall be able to stand a good deal of knocking about.

Flush with the top of each side a piece of 1-in. by ½-in. wood is nailed for the drawer to run on. The casing, made of any suitable wood available, is as wide as the drawers *plus* the runners, and from front to back as deep as the drawer outside. Ledges are nailed to the inside to carry the drawer runners (Fig. 58). A fair clearance should be left

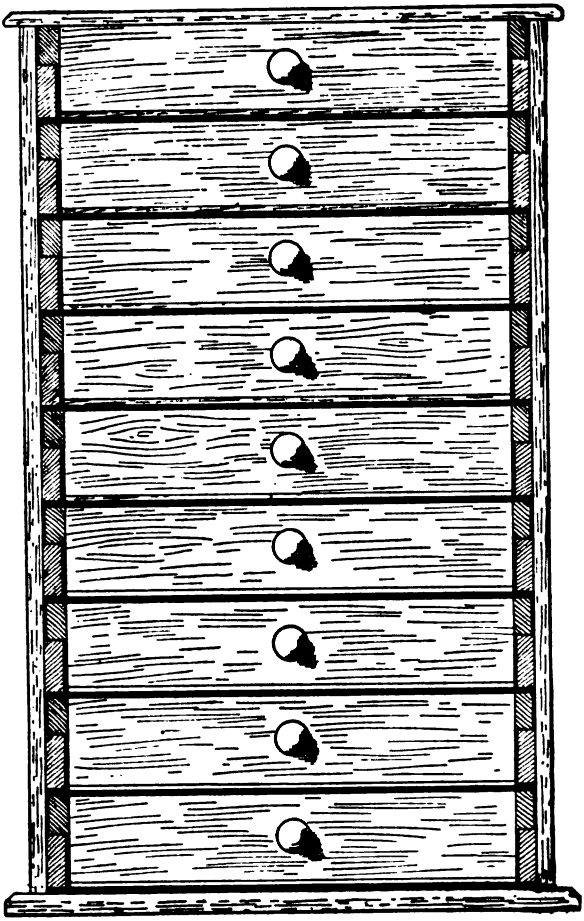

Fig. 58.—Tool cabinet made out of sweetmeat boxes.

between drawers, as in a case like this one requires the drawers to open and shut very easily, and not jam if something sticks up a fraction of an inch too far.

Any divisions in drawers should be firmly fixed and touch the bottom all along, so that nails and other small objects may not get jammed underneath.

Suitable handles for the drawers will cost but a few pence at the ironmonger's.

Any one who has a workshop is advised to knock up a cabinet or two on these lines if he is not already provided, as drawers are vastly preferable to boxes for storage.

A TOOL CASE.

This nest of drawers, which is of a more finished kind than that just described, is suitable for sets of gauges, bits, drills, special chisels, and other tools best kept in drawers under lock and key. It is 2 ft. high, about 14 in. wide, and 11 in. deep on the top. The depth of the drawers ranges from 2 in. at the top to 4 in. at the bottom. The case itself is made of ¾-in. wood, nailed together. To allow for the front locking-stile, the top must project 1 in. beyond the front of the sides. A narrow base or plinth is nailed round, and to make a wider surface for it on the front a fillet is fixed under the bottom, as shown in Fig. 59, *b*, at M. The drawer fronts are of 1-in. wood, and the sides,

backs, and bottoms of ⅛-in. The sides are nailed into the fronts, which are cut out to receive them, as shown at Fig. 59, *b*, K, and the bottoms fixed as at K and J, the grain running parallel to the side.

A drawer runs on a slip screwed to the sides. A reference to Fig. 59, *b*, shows their position between

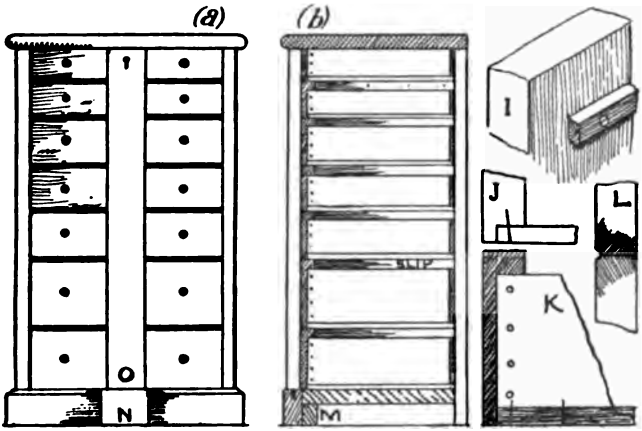

Fig. 59.—Case for tools.

the drawers. A view of a slip is given in Fig. 59, I. The drawer front shuts against the slips supporting the drawer above, and so must be deeper than the sides by the depth of the slips.

When the drawers are made, the fitting should start from the bottom. Fit the drawer, screw or nail the slip above it, and plane the top edge of the drawer front down to a little below the slip. Con-

tinue this until the top drawer is fitted. If the edges between the drawers be planed off, as seen in Fig. 59, *b*, L, the joint will not show. Small brass knobs or screw rings make suitable handles for the drawers.

To take the "locking-stile," O, a block, N, 3 in. long and 1 in. thick, is let into the plinth and nailed on. The stile is 2½ in. wide and ¾ in. thick. At its bottom a dowel is glued in; or, better still, a plate with a brass pin is screwed on. This dowel, or pin, drops into a hole in the block, as the section (Fig. 59, *b*) shows. At the top of the stile is sunk in a lock which will shoot its bolt into the top and secure all the drawers.

A HANDY PORTABLE TOOL BOX.

There are lots of little jobs about a house which require tools to be taken to them, as the job cannot be taken to the workshop. It is therefore desirable to have a box for transporting the most commonly-used tools and an assortment of nails, screws, and other odds and ends, so disposed that they can quickly be got at.

Fig. 60 gives a view of a chest which fulfils the purpose very well. It contains a top chamber with flap lid for tools; and two drawers, divided into compartments, for etceteras.

Its over-all dimensions are: 15 in. long, 8 in. wide, and 12 in. deep. Sides, ends, bottom, and

top are made of ½-in. wood planed down on both faces, so that the actual thickness barely exceeds $\frac{7}{16}$ inch.

The two drawers are the full length of the box and 2¼ in. deep. The front ends are of the same stuff as the ends of the box, but the inner end, sides, and bottom are of ¼-in. wood.

The bottom and lid of the box present no difficulty. The long sides must have two grooves cut in them for sheets of ¼-in. wood which form the bottom of the tool-container and separate the lower from the upper drawer. These sheets should be cut with their shorter dimension in the direction of the grain, so that there shall be no bending and warping, which certainly would occur if the grain did not run from side to side of the box; and must be a tight fit, so as not to come out with the drawers.

The most workmanlike method of making the corner joints of case and drawers is dovetailing. (See p. 29.) But for a rough chest, which is very much better than none at all, it will suffice to overlap the parts in the usual manner. Corner pieces carefully fitted and glued in and nailed will increase the strength considerably.

Holes must be bored in the back of the drawer spaces through which to push out the drawers. The latter can be secured by a vertical rod passing down through the end of the box and the fronts of the drawers. The boring of the hole requires

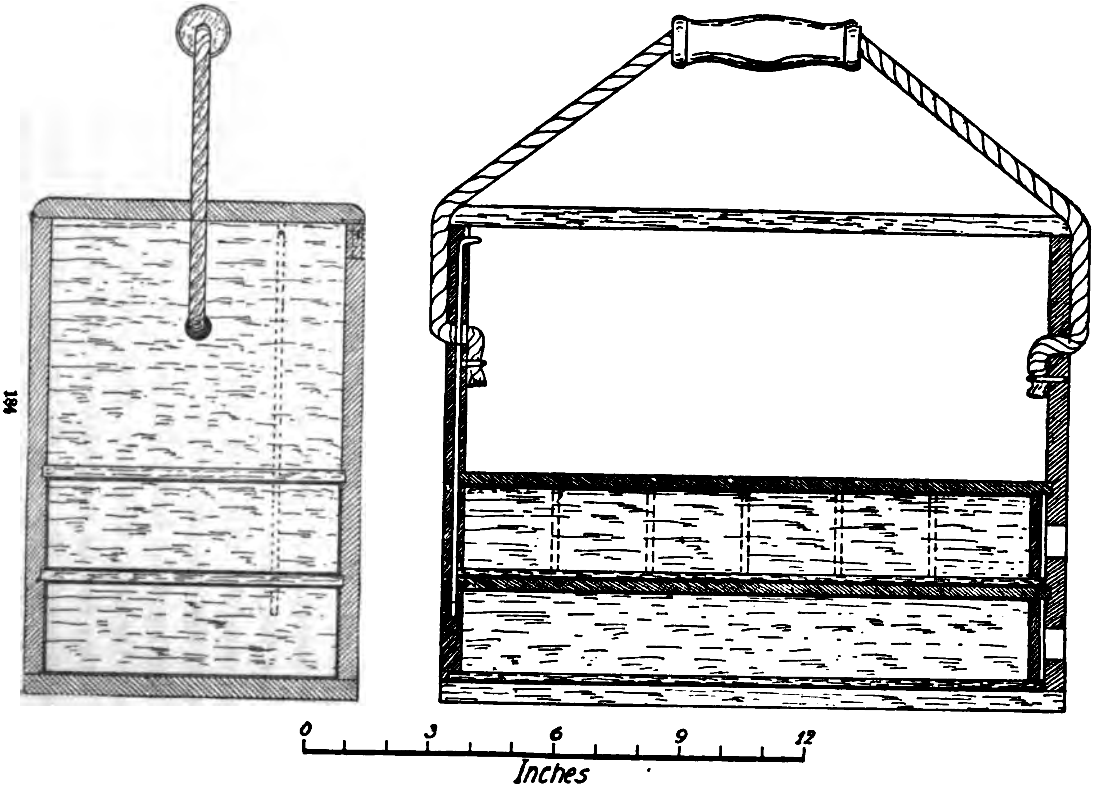

Fig. 60.—A portable tool box.

some care, and the beginner may find it a desirable alternative to use staples driven into the inside of the end and fronts, in which case only the two horizontal partitions will need boring. The securing rod is bent over at the top end. If the box be fitted with a lock and key, the contents will be secure from "borrowing" by unauthorized persons.

For a handle use a piece of rope passed through the ends of the casing and stapled on the inside. If a wooden handle of some kind can be fitted to the middle of the rope, so much the better for the hands, for when full of tools the chest will have a considerable weight.

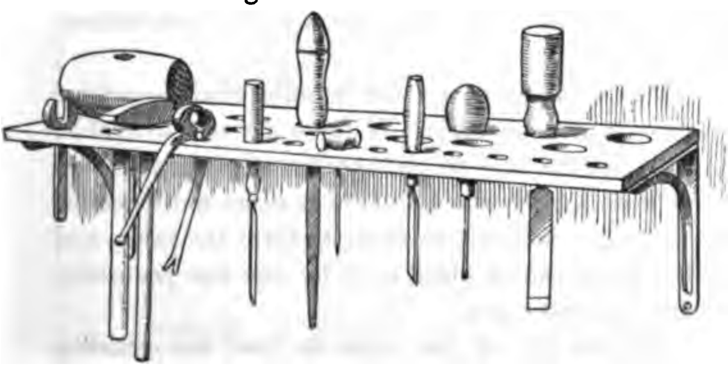

Fig. 61.—A useful tool rack.

A TOOL RACK.

To keep tools handy, and yet in some kind of order, adequate racks, fixed on or near the work-

bench, should be provided. A leather strap nailed at intervals to an upright board, to make a series of loops, is the simplest and most quickly constructed. A more efficient rack is shown in Fig. 61. This consists of a bracket having a shelf perforated with centre-bit holes of different diameters, the largest being at the back. The width and length are governed by the number of tools to be accommodated; but it is wise to make considerably more holes than will be occupied in the first instance.

HOW TO MAKE A POLISHING MACHINE.

The best, and certainly the easiest, polishing is done with a special machine, which is not difficult to make.

The remains of an old treadle sewing-machine provide a good basis. If these be not available, you may be able to pick up for a very small sum at least the fly-wheel and crank of an old machine. A wooden box can be made to form the table, and the wheel can be fitted to it by any one possessing any ingenuity at all.

On the top of the table is fixed the grinding spindle. Procure a piece of iron tube, about half an inch in diameter outside, and six inches long; a piece of brass tube slightly larger and just big enough for the iron tube to go inside it; and a piece of round bar iron fitting as tightly as

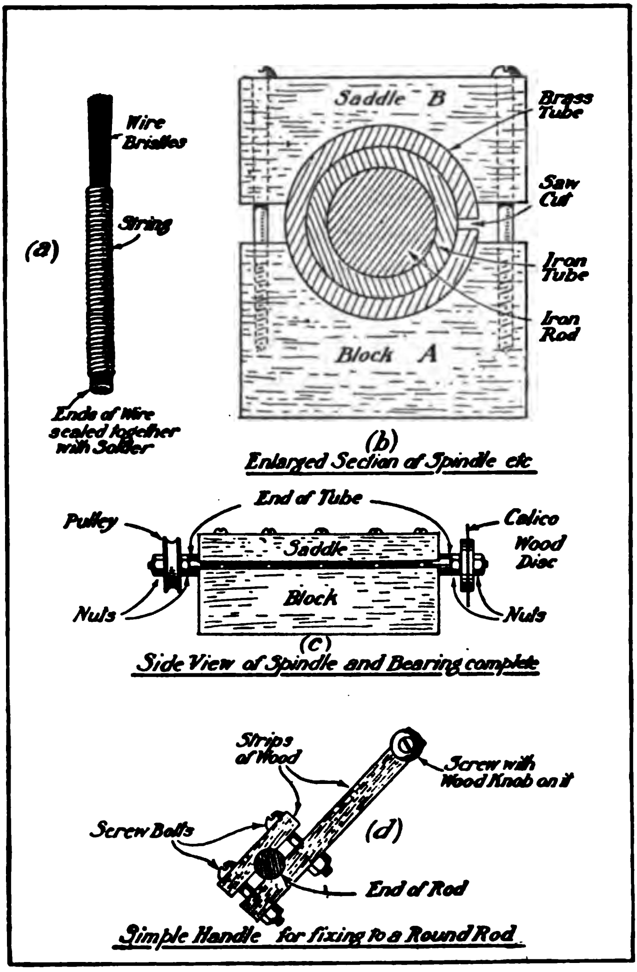

Fig. 62.—Metal-polishing apparatus.

possible inside the iron tube, and long enough to project about an inch and a half at each end.

Ask the ironmonger from whom you buy it to cut a screw thread for about an inch and three-quarters at each end of this rod and supply four nuts to fit the thread.

Next, get a block of wood, A, about five and a half inches long, and cut in it a groove in which the brass tube will lie comfortably (Fig. 62, *b*). Out of another piece, B, make a saddle to straddle the tube, so that, when it is screwed down to the block, the tube will be clipped tightly between the two. Slit the tube from end to end with a saw, on one side only, and remove the "burr" on the inside of the cut with a scraper or round file.

Now take the iron tube and polish it up smooth with emery cloth. Then do the same with the rod, so that it may slip in and out easily, but without looseness.

Put one of the nuts on and screw it home as far as it will go. Then put on, in like manner, a small round disc of wood half an inch thick, finally screwing on the other nut, so that the disc is firmly held between two nuts. Cut a groove in the edge of the disc to hold the driving belt.

Now put the brass tube in the groove in the block with the iron tube inside it. Lay the saddle in place, screwing it down carefully with several screws on each side. The brass tube, being cut

down one side, will close up slightly when thus pressed upon, and so can be made to hold the iron tube just tightly enough to turn smoothly and sweetly. Of course it must be kept well oiled.

Now cut a dozen discs of calico, three or four inches in diameter, with a hole in the centre of each. Slip the rod through from left to right and put the third nut on the right-hand end, screwing it hard home against the end of the iron tube. Then put on a small disc of wood; then the discs of calico; then another disc of wood, and finally the other nut.

Then stretch a piece of cord, well covered with tailor's wax or powdered resin, round both fly-wheel and the pulley, and set the treadle going. Instantly the calico wheel or "mop" will stiffen itself out by centrifugal action, and its edge will form a fine polishing surface. Hold what you want to polish against it.

Other wheels may be made for fixing between the two right-hand nuts as required. One or two may be covered with emery cloth of various grades, glued on. Another may be covered with leather, likewise attached with glue. A small grindstone or a small emery wheel may be fixed upon the spindle, if desired.

It may be well in conclusion just to review the purpose of the various parts just described, and so make the construction quite clear to the reader.

The iron tube forms the spindle; it must be just a shade longer than the brass tube.

The brass tube forms the bearing in which the spindle turns.

The iron rod forms the means by which the driving pulley is attached to the spindle at one end and the grinding or polishing wheel at the other end. The pulley is gripped between the first and second nuts, the spindle between the second and third, the wheel between the third and fourth.

To Polish a Round Rod.—It is often convenient to polish a round rod by turning it round against the grinding material rather than by applying it to a moving grinding surface. For this purpose get a block of wood and cut a V-shaped groove in it. Then fit on to the end of the rod a handle, which can easily be made of two pieces of wood drawn together by two small screws and nuts. (See Fig. 62, *d*.) A handle of this kind should be made and kept at hand, since it will often come in useful for odd jobs.

Hold the rod down in the groove with a piece of wood to which has been applied some emery powder and water, or which is covered with emery cloth. To give the final polish a piece of flannel may be laid in the groove with some fine powder on it, the rod being held down with a pad of similar material. Thus the rod is turned round and round

in contact with the grinding surface, and a very good polish will result.

SOLDERING.

Soldering is to metal-work what gluing is to woodwork—a quick method of attaching two parts together without the use of nails or screws or rivets. Gluing is not so easy a matter to carry out effectively as it may appear. With soldering the case is the other way about, for many people imagine it to present difficulties which do not exist.

That any person who professes general handiness should be able to do soldering goes without saying. Many kettles, pots, and pans, and other liquid-containing utensils, are laid aside as useless because they have rusted through in a few places, sprung a leak in a joint, lost a handle or spout, and so on; though a few minutes with a soldering-iron would extend their lives considerably. Lamps often need a touch of solder in various parts of their anatomy. On the constructive, as opposed to the repairing, side there are innumerable objects which can be made with the aid of solder, but not without it; and as soldering is referred to many times in this book the reader will do well to take the following hints to heart.

Soldering Tools, etc.—The most generally useful item of the outfit is *the copper bit*, which, besides

melting the solder, will draw it along a joint. A large bit containing a pound and a half of copper will be found most satisfactory for household repairs; but it should be supplemented with a small tool of similar shape for delicate work. The larger the bit, the longer it retains heat; but the longer it takes to get hot, and the more clumsy it is to handle.

The bit with large swivelling head (Fig. 63, *c*) has distinct advantages over the straight bit, as the head can be set at any angle to the shank, which makes it very handy for getting into corners.

Many jobs may be done without the aid of a bit, by merely heating the parts to be joined until the solder runs. So we may add to our equipment an ordinary spirit-lamp and a little blow-lamp (Fig. 63, *e*). The last is invaluable for dealing with cases in which the parts must not be touched with a tool for fear of disarranging them.

Another very useful possession is the combined benzoline blow-lamp and bit shown in Fig. 63, *f*. The flame of this will keep the bit at a proper temperature for a long period; and if the bit be removed, the lamp can be used to heat the metal directly, so that the tool serves two purposes. The hollow brass stem contains a wick, which is saturated with benzoline or petrol. The burner end having been heated by spirit burning in the pan A, or by a spirit-lamp, the apparatus is ready for work.

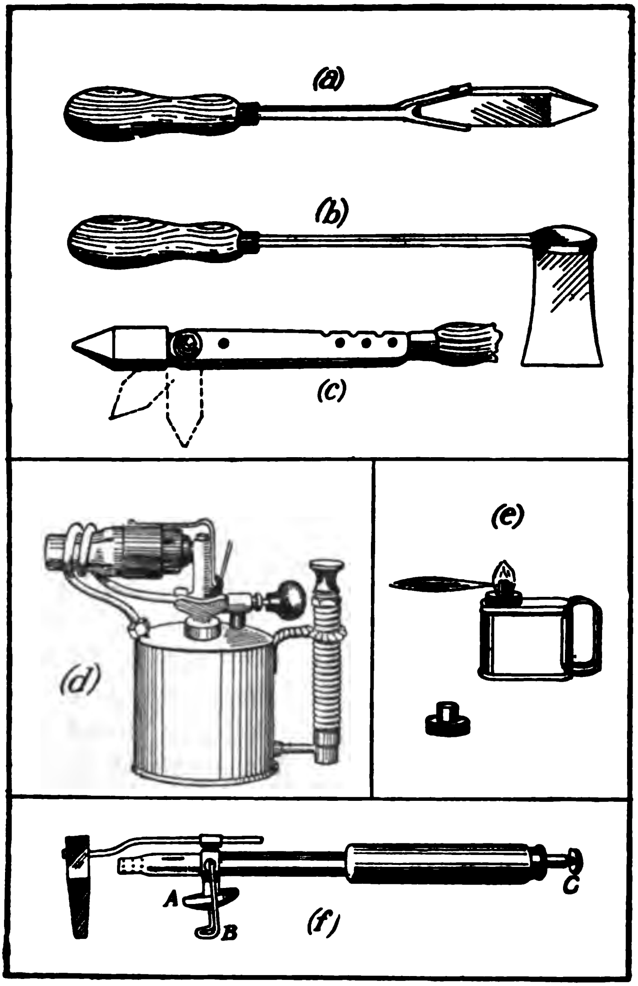

Fig. 63.—Soldering tools and lamps.

For dealing with large pieces of metal, a painter's blow-lamp, or a brazing-lamp (Fig. 63, *d*), may be strongly recommended. In the absence of such a help the heating will have to be done over a clear fire.

Solders.—For very small jobs, and for "tinning" surfaces in readiness for soldering, a compound of solder in dust form and a flux is extremely useful. Compounds of this kind are sold by all ironmongers. For all-round work there is nothing to beat stick solder, in bars not more than ¼ in. thick. Besides the ordinary "bit" solder, which melts at about 350° F., one should have a small supply of soft blow-pipe solder, fusing at a much lower temperature. This softer stuff proves useful when two joints have to be made close together: the hard solder being used for the first, and the soft for the second.

Fluxes.—To keep air away from the metal while the solder is getting a hold, one must use a flux, except in the case of perfectly clean tinned iron. The most generally useful flux is *chloride of zinc*, as it gives excellent results on iron, brass, copper, and zinc. It has, however, the defect of rusting iron very badly if not carefully washed off with an alkaline solution of ammonia or washing-soda, followed by an application of pure water and a thorough drying, after the joint has been made. As an alternative one may use *resin* for the metals named. The proper flux on *lead* is *tallow*.

Preparing Chloride of Zinc.—Cut up odd bits of zinc into small pieces, and cover the bottom of a jampot with them to the depth of a quarter of an inch. Take the jampot *out of doors* and pour into it a few ounces of "commercial" spirits of salt (hydrochloric acid). A great fizzing commences at once, and a very unpleasant gas is given off. When the boiling stops, add more zinc; if this does not cause further ebullition, the acid has been properly "killed," and is ready for use. Strain the liquid through a piece of calico or a filter paper into a clean bottle, which should be plainly labelled "*Poison.* Chloride of Zinc, Soldering Flux." Keep it away from tools, as killed spirits and the fumes from it are terrible rusters of iron and steel objects generally.

Resin is most conveniently used in the powder form, as it can be dusted over the joint in the quantity required for the work.

Using the Bit.—We will suppose that the job before us is the making watertight of the folded joints of an ordinary tin box. ("Tin," when applied to boxes, canisters, etc., may always be assumed to mean tinned iron.) The metal on each side of the joints is scraped bright with an old knife or other suitable instrument, and a sharp point is drawn along the cracks to remove any lurking dirt. Let it be borne always in mind that *dirt is the solderer's greatest enemy*, as it keeps the

solder out of contact with the metal, and so prevents the essential continuity of the two.

Meanwhile the copper bit has been heating in the fire. When drawn out it has perhaps a dirty purple look, and the tip, if rubbed with a file, turns black again almost immediately. Put it down to cool for a minute or two, and then try again. The filing now leaves the metal bright, the whole of the tip is treated, and plunged for a second or so into a jampot containing half an inch of raw spirits of salt, which has been put ready beside the tin box. The acid cleans off any remaining dirt and leaves the tip ready for tinning.

A stick of solder is now dipped into a second gallipot holding chloride of zinc, and applied to all four sides of the tip of the bit. Little blobs of solder form on the copper, which is dipped into the flux, and instantaneously the solder covers all the bright area. Our "bit" is now "tinned" ready for use. The whole process of tinning occupies but a few seconds.

On to one end of the joint to be treated melt a blob of solder from the stick. Press the end of the bit on to the blob, and as soon as it melts, draw the bit slowly along the joint. If the solder follows obediently, well and good. If it does not, dip a small glass rod or tube into the flux, and moisten the joint from end to end. Then the solder will run after the bit until the supply is exhausted, when

a second blob is required. Use the least possible amount of solder, so that the work may look neat.

On the second joint the solder may not run, but form ridges under the bit. This means that the bit is now too cold, and must be reheated. Push it into a clear hot part of the fire where there is no smoke. While it heats, a rag is procured wherewith to wipe the point clean presently. Be careful not to let the bit remain in too long now, for at a certain temperature the tinning will be burned off, making retinning necessary. So after a minute or two the bit is withdrawn and held a couple of inches from the cheek. With practice one learns to judge by the feeling of warmth when the bit is properly heated. A rub with a rag and a plunge into the raw spirit, and the tip is fit for continuing the work.

When all the joints have been run with solder, they are washed with soap and water to remove all acid, and then examined for tightness. If the solder makes a continuous surface all along, one may assume that things are right. But any little pits of which one cannot see the bottom should be melted out with the bit. The joints of model boilers or of vessels to hold water or air under pressure cannot be finished too carefully, as the minutest hole may prove a very troublesome leak. Absolutely clean surfaces and a properly heated iron mean good joints.

Mending a Hole.—Here is a rusty bath-can with

a hole in the bottom. It has been put aside as useless, but may be worth examination. One tests it by prodding the bottom viciously with a bradawl. If the tool goes through in many places, the can has evidently served its time ; but if it proves invulnerable except just round the hole, it will do good work yet.

First of all, enlarge the hole till you get to sound metal. Then scrape the metal bright half an inch all round the edge of the hole, and cut out a disc of tin which will cover the hole with a quarter of an inch to spare in all directions.

For this job a spirit-lamp may be used. Turn the can bottom upwards, and prop it in such a position that you can get your hand inside it conveniently. Smear a little tinning compound over one side of the patch and round the hole. Hold the patch in a pair of pliers over the spirit-lamp till the solder runs, and afterwards heat the bottom of the can from inside till the metal round the hole is also "tinned." Without moving the lamp apply the solder stick to the can and melt off a blob or two. Then lay the patch in place and press it down hard. The solder will soon run out all round the patch. You may now remove the lamp ; but keep the pressure on until the solder turns dull, which means that it has set, and that the job is finished. Should the patch prove sulky, apply a little zinc chloride.

Mending a Crack.—We may next take the case of a bucket, the bottom of which has been cracked by a blow. The metal is thick and the crack so deep that the proper cleaning of it presents a difficulty. The simplest course is to deliberately enlarge the crack, by driving in an edge tool, till the metal can be got at and scraped or rubbed with a flat jeweller's file—a very handy little thing to keep by one for small jobs. The lips of the crack are then brought together again by hammering, flux is applied, and solder run in with the bit. As the metal is thick, keep the bit in contact for a considerable time to ensure the solder getting through. If the job be done properly, solder should be visible on the farther side.

Various Cases.—If a joint have to stand great strain, it is advisable to make the solder run right through, and show on the farther side, as this proves that the surfaces actually in contact have both been gripped. In such a case one should, if possible, "tin" one or both parts before bringing them together, to ensure the solder getting a good hold. The mere heating of the parts will, in many instances, suffice to make the joint if the surfaces have been previously tinned.

If a light piece of metal have to be joined to a massive piece, the second must be heated right through to the melting-point of the solder. It is impossible to solder a strip of tin to, say, a cold,

thick iron plate with a bit, as the iron plate would carry off the heat. But if the plate be well heated over a clear fire, or with a blow-lamp, until it can melt the solder on its own account, the joint is made easily enough.

When one has to deal with very small parts which have to be accurately adjusted and would be disturbed by a bit, "tin" each part well and stand one on the other, or keep them together by pressure, while the solder is remelted with the spirit flame.

In all cases where trouble is to be anticipated, it is a good rule to distribute solder on the parts separately, and fuse it again after the parts have been brought together and put under pressure.

General Hints.—Cleanliness is of the first importance—chemical cleanliness, such as is produced by scraping; also sufficient heat.

It is impossible to solder *aluminium* with ordinary solder, and *cast iron* takes solder very unwillingly. *Brass*, *copper*, *gun-metal*, *wrought iron*, and *steel* are all very amenable. *Zinc* must be handled carefully, as it has a low melting-point, and an easily fusible solder and moderately hot bit should be used. *Lead* requires tallow as flux, and is soldered by "wiping," a process which requires considerable skill, and had better be left alone by the average amateur.

Soldering with Foil.—The foil used for lining tea

chests makes a convenient solder for small work. The parts to be joined are cleaned, moistened with a solution of sal ammoniac, and laid together with a piece of the foil doubled once or twice between them. They are then clamped or tied together with wire, and subjected to the heat of a hot iron or spirit or gas flame until the foil melts.

A useful form of clamp for the purpose is shown

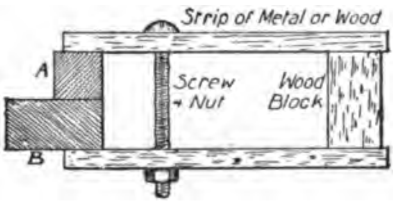

Fig. 64.—Clamp for soldering with foil.

in Fig. 64. The screwed bolts may be purchased cheaply at any ironmonger's.

Steam Pressure, Heat, and Nature of Solder which may be used.—The following table will be of use to the amateur boilermaker :—

Pressure of steam above atmospheric pressure in pounds to the square inch.	Heat in degrees Fahrenheit.	Most fusible solder permissible.
15	250·4	Blowpipe solder containing bismuth, melts 310° F.
20	259·3	
25	267·3	
30	274·4	
50	298·0	Blowpipe solder without bismuth, melts 340° F.
75	320·3	Plumber's solder, melts 370° F.
100	338·0	Silver solder.

CASTING IN LEAD.

Many small parts of toys and small mechanisms are made of lead and its alloys, and if broken cannot be easily replaced. The ability to make simple castings in easily fused metals may therefore come in useful on occasion.

The mould is made of plaster of Paris, pulped paper, or casting-sand. The first is perhaps the most convenient for small objects ; the last has the advantage of being usable over and over again.

Objects with one flat side, or which taper in one direction only, can be cast in a one-piece mould. The wheels of a toy locomotive, for instance, in many cases could thus be dealt with ; and for sake of illustration we will assume such a wheel to need copying.

The parts of the broken wheel are arranged carefully, flat face downwards, on a board previously waxed over, and surrounded by a square frame of wood rather larger than the wheel and half an inch deep. Some plaster of Paris is mixed with water to form a thick cream, poured into the frame and left to harden. The mould, as it now is, is lifted off the board, and set aside to dry thoroughly, after the old wheel has been lifted out.

Drying complete, the mould is laid flat, and all the depressions left by the pattern are filled in flush with molten lead poured from an iron spoon

or small ladle. Err on the side of excess, as any surplus metal is easily filed or cut away afterwards.

If the pattern taper in both directions—as, for instance, a round-spoked wheel does—the mould must be made in two parts. Two frames of the same size are constructed to make a close fit when laid one upon the other, and are provided with pegs and holes in the edges to prevent them moving one over the other when brought together. The lower half is filled flush with liquid plaster, and when this is stiff enough the pattern, previously waxed, is pressed down into it flatways until it is exactly half embedded. When the plaster is hard, wax its upper surface well to prevent the upper half adhering, lay the frame of the top half of the mould in place, and fill this also with the plaster. Mark the frames so that they shall be put together correctly after separation.

The upper mould having set, lift it off and remove the pattern. Drill a pouring hole and a small air vent through what will be the upper half mould. Put the two halves together again, and pour in the metal slowly but steadily, until it rises in the holes. In a few minutes the mould may be separated and the casting taken out.

Very simple objects, such as cylindrical clock weights, can be cast in holes made in casting-sand with a wooden rod of the diameter required, or in

holes sunk in hard wood with a centre-bit. In either case the mould will probably have to be broken up to extract the casting. If a hook or loop be required at the top of the weight, a suitable piece of wire should be arranged in the mould so as to be thoroughly embedded in the metal.

Moulds for castings in low relief—replicas of medals, coins, etc.—can be made by pressing the original into blotting-paper pulp. When this is dry, rub it over with black lead and fill in the depression with molten soft solder.

Caution.—It is essential that moulds, especially two-part moulds, should be thoroughly dry before molten metal is poured in. The presence of damp might generate steam, and, even if it did not lead to a violent explosion, at least ruin the casting.

Chapter XI.

WINDMILLS.

ALTHOUGH requiring thoroughly sound workmanship, the construction of a windmill is not a very difficult nor an unduly expensive undertaking; and it is, therefore, rather surprising that this interesting motor should have received so little attention from amateur engineers.

The uncertainty of wind power is, of course, the chief reason why it is not more frequently made use of. The wind, however, blows with greater regularity than is often supposed, and a mill seldom need be idle for more than two or three days on end.

There is an old saying that "'tis money makes the mill to go;" and there is little doubt that, if the state of trade demanded it, the old-style windmill could grind for some 3,000 hours per annum, which presupposes that the wind velocity is not below 14 or 15 miles an hour during that number of hours.

But for pumping, or even for charging accumu-

lators, a 10-mile breeze is not to be despised, in spite of the fact that its energy is less than one-third that of a 15-mile breeze. In favourable situations a wind velocity of not less than 10 miles per hour will probably prevail for at least 4,000 hours per annum. Calms of two or three days' duration are not uncommon, but a week without wind is exceptional.

Theoretically, the power of a windmill varies in the same ratio as that of the wind—namely, as the cube of the velocity of the latter; actually, however, the available power of the mill will tend to increase more nearly as the square of the wind's velocity, for the reason that the speed of the former cannot be permitted to exceed certain limits.

The sail surface of a wind motor is more efficiently disposed in the long, narrow sweeps of the old-fashioned four-armed windmill than in the closely placed vanes of the modern wind-engine; but the latter type is more suited to pumping, as it starts more easily, and will run in lighter winds—and is more compact and of slower speed. A mill of the second type has, therefore, been chosen for description.

For the wind-wheel a diameter of 5 feet is proposed—a size which should develop approximately one-twelfth of a horse-power in a 15-mile wind, at about 150 revolutions per minute. If it be

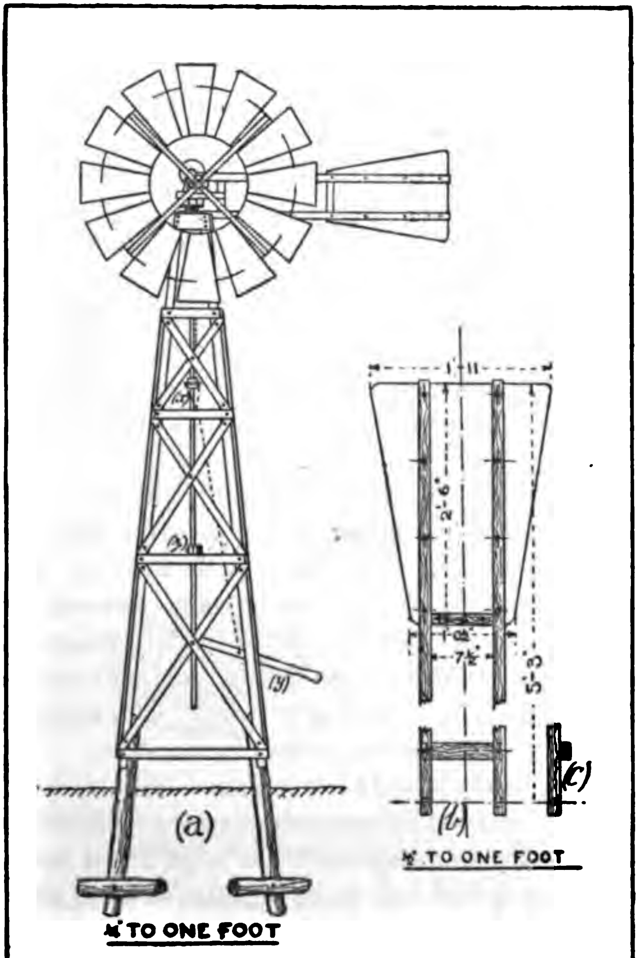

Fig. 65.—Details of windmill. (*a*) General view: tail turned to "off" position. (*b*) Details of tail. (*c*) Cross-piece.

desired to make a larger or smaller mill, it is hardly necessary to point out that the power will be proportionate to the *square* of the diameter of the wind-wheel.

In the design which follows, the use of castings has been avoided, as it seems a waste of labour to make somewhat complicated patterns when only one set of castings is likely to be required; and, further, the machining would present difficulties unless a good-sized lathe were available. The materials are consequently limited, as far as possible, to timber and wrought iron, in forms easily obtainable.

The Tower.—By reference to Fig. 65, *a*, it will be seen that the tower is composed of four uprights of 2-in. by 2-in. stuff, with 2-in. by 1-in. bracings and girts, the whole being fastened together with ⅜-in. bolts, fitted with washers of ample size. Good, sound yellow deal will answer the purpose, but pitch-pine would be preferable where expense is not a serious consideration.

A height of about 12 feet is shown, but this must, of course, depend upon circumstances. The bottom of the wind-wheel should be at least 2 feet above any trees or buildings in its vicinity, so as to avoid eddies in the wind. In this country exposure to the S.W., W., and N.W. has usually to be considered in the order named, but it is obviously almost equally important that the wind should flow as

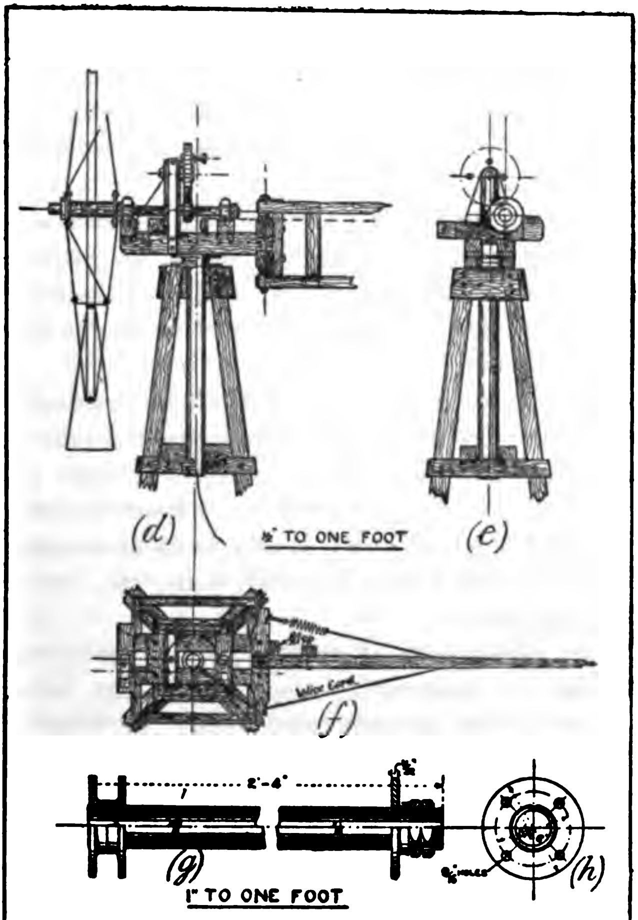

Fig. 66.—Details of windmill.

freely *away* from a windmill as towards it. If the tower require to be higher than shown, the cant of the sides should be continued at the same angle, in order to broaden the base, the extended portion being well braced.

In some cases, a short tower from the roof of a workshop or other building may answer the purpose, but it need hardly be said that the higher the wheel the better, as the wind is retained by the surface of the ground.

The woodwork of the tower should be thoroughly well painted with at least three coats, the priming being composed of white lead with a little red lead added. All joints should be well coated *before* being put together, and it is also desirable to paint, or dip in boiled oil, all screws, bolts, etc., before inserting them.

Two applications of creosote, or of one of the well-known preservative wood stains, one before and one after erection, could take the place of painting. A further application at the end of a year would be advisable. The timbers in the ground must be tarred.

The Turn-table (Fig. 66, *d*, *e*, *f*), which carries the wheel and tail vane, is built up of 2½-in. by 2-in. timber, and 2-in. bore galvanized wrought-iron "water" tube and flanges, the latter being easily obtainable from an ironmonger. The upper flange, which forms a support for the timber framing,

is to be countersunk (this can be easily done with a half-round file), and screwed very tightly on to the tube as far as it will go; the end of the tube should project slightly beyond the face of the flange, so that it can be riveted over to fill the countersink, and thus leave no possibility of unscrewing (see detail drawings, Fig. 66, *g*, *h*). The two loose flanges, which are bolted to the framework of the tower, are for 2-in. pipe, but the thread has been carefully filed away, so that they may slide freely, but without shake, on to the tube, the upper loose flange forming a footstep bearing, and the lower one a guide, for the turn-table. Windmill makers now mount the turn-table on a ball-bearing to ensure that the mill head may turn freely; hence careful fitting is essential here. The two back nuts are to guard against any possibility of the turn-table being lifted out of place.

The Head.—What woodwork is required for the head (the part carrying the wheel spindle) will be evident from Fig. 66, *d*, *e*, *f*. The joints are simply notched and secured with $\frac{3}{8}$-in. bolts. The upright, which carries a bolt or pin for the spur-wheel to revolve upon, is stayed in front and at the sides by a piece of hoop iron; and the tail vane swivel is a piece of $\frac{1}{2}$-in. bore tube with back nuts and washers, through which passes an iron bolt, or rather a piece of iron, screwed at each end

and fitted with four nuts and washers. All woodwork, as well as bolts and screws, should be painted before being put together, as recommended in the case of the tower.

Wheel Shaft.—For the wind-wheel shaft and hub, seen in the various views and in detail in Fig. 67, *k*, *l*, wrought-iron tubing and flanges have again been called into service. The bore of the tube is ¾ in. (nominal), the outside diameter being $1\frac{1}{16}$ inches. Both tube and fittings should be of "steam" quality, which is a gauge thicker than the "water" quality. A slight skim over in a lathe would be an advantage, but careful filing followed by emery cloth will do, if a lathe be not available. The tube is screwed a good way up at one end to receive the flanges forming the hub, which are screwed on and secured on one side by back nuts, and on the other by a distance piece composed of 1¼-in. bore tube.

To close the open front end of the tube and to give a finish, a ¾-in. "cap" is fitted. Two plummer blocks, with brasses 1½ inch. long and fitted with Stauffer grease lubricators, are required as bearings for this shaft. Perhaps these had better be purchased; the cost would probably be under 15s. The exact diameter of the finished shaft must be stated when ordering, as plummer blocks are stocked only in regular sizes—for example, 1 in., 1¼ in., etc.; the usual custom is

to charge for the next larger size when an odd diameter is asked for.

In so small a mill some form of reducing gear is almost a necessity, as a speed of 100 to 150 r.p.m. is too fast for a pump; hence a spur-wheel and pinion giving a ratio of not less than 3 to 1 will be required. The pinion should be at least 2¼ in. diameter at the pitch circle, for it has to be bored to fit the wind-wheel shaft, from which it follows that the spur-wheel will be of about 7 in. diameter. Probably some gear-wheels from a lawn-mower would be available or, at least, could be used as patterns; failing this, cycle sprocket wheels and chain would prove a very fair substitute.

The pump and its connections will be referred to later, as we have now to consider the tail vane and the governing arrangements for controlling the speed of the wind-wheel.

It will be noticed that the axis of the wind-wheel lies to one side of the centre line of the head, the centre lines being 1½ in. apart, and that the arm which carries the tail vane is hinged to the head. This want of balance creates a tendency for the wheel to turn out of the wind, but this is counteracted by the action of the spiral spring (see Fig. 66, *f*). If the wind be light, the tail vane, which acts, of course, as a weathercock, will keep the wheel normal—that is, at right angles to the

direction of the wind—in which position the wheel will develop its full power. If, however, the wind pressure increases sufficiently to overcome the resistance of the spring, the head will alter its relative position to the tail vane, with the result that the wheel will turn more or less obliquely to the wind and receive its force with diminished effect. To stop the mill, the spring is extended by an external agency—namely, the wire cord seen in Fig. 66, *d* and—which causes the wheel to turn parallel to the vane, so that it presents only its edge to the wind.

The Tail.—An enlarged view of the tail vane is given at Fig. 65, *b*. The arms are of 1½-in. by 1½-in. stuff, tapered to the outer end. A fine saw cut is run up to a distance of 2 ft. 6 in. from the outer end to receive the vane, which may be of galvanized sheet steel of about 20 S.W.G. The cross-piece, shown at Fig. 65, *c*, is to act as a stop when the vane is pulled parallel to the wheel. The inner end of the vane is stiffened by a 1½-in. by ½-in. strip at each side where the steel wire cord and the spring are attached. The last may be a large-sized bell spring, but some experimenting will be needed to obtain the requisite adjustment.

The cord passes over two pulleys and down the turn-table tube. It will be necessary to attach the end of the cord to a short cylinder of hard wood or metal, say, from 2 in. to 3 in. in

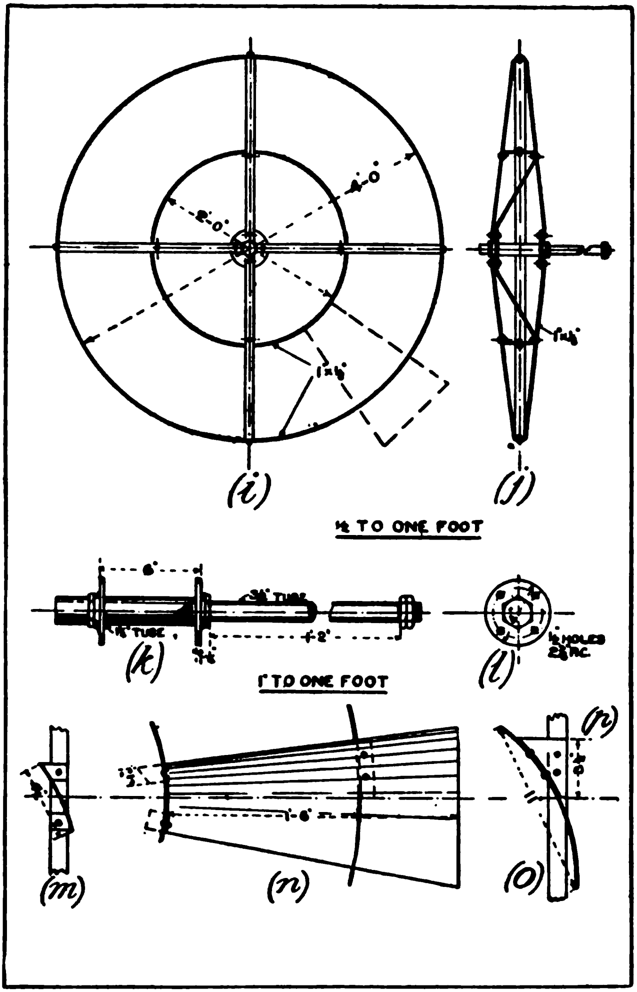

Fig. 67.—Details of windmill. (*i*, *j*) Frame; front and side views. (*k*, *l*) Axle of wheel. (*m*) Attachment of inner end of vane to inner ring of frame. (*n*) Vane on rings. (*o*) Attachment of vane to outer brackets by bracket (*p*).

diameter (x in Fig. 65, a), which revolves with the turn-table, but can be slid up or down. The easiest plan is to cut a hole through the axis of the cylinder to fit the (square) pump rod. If a groove be now cut in the circumference of the cylinder, and two pieces of iron be bent into the shape of eccentric straps and placed in the groove, cords can be taken from the two bolts which unite the straps. These two cords should be joined to another which is taken to a reel or a lever, y (Fig. 65, a), at the base of the tower. In this way the position of the tail vane can be regulated from a stationary point.

The Wheel.—Undoubtedly the most interesting part of the undertaking is the wind-wheel. The framing (see Fig. 67, i and j) consists of an inner and outer ring of 2 ft. and 4 ft. diameter respectively, and four double arms with cross stays and diagonals; the whole being made of 1-in. by $\frac{1}{8}$-in. steel, preferably galvanized. This section is largely used for making brackets for roof guttering, so should be easily obtained from a builders' ironmonger. The ends of the arms should butt tightly against the back nuts which secure the hub flanges. A wheelwright could very quickly form the rings in his tyre-bending rolls, if any difficulty be experienced. In bending the arms, care should be taken to avoid too sharp a radius, so as not to crack the material; and it would be well to arrange that the arms should require to be slightly sprung

forward in order to insert the front flange bolts, that they may be put in tension and stiffen the wheel against wind pressure.

Vanes.—There are twelve vanes, of which details are given in Fig. 67. These vanes should be formed of galvanized sheet steel (about 22 S.W.G.) or, failing this, stout sheet "tin." To stiffen them, the vanes must be curved to a radius. This can be done by bending them over a shaped block of wood, or by recourse to the tinsmith's rolls. The connection to the inner ring is made by leaving ears on the smaller end which are afterwards turned at alternate right angles. It would be as well to leave these ears rather long, and to trim them *in situ.* The attachment to the outer ring is by a bracket, seen at Fig. 67, *o*, which may be made from the same material as the vanes. As it is bent to two radii—those of the vane and of the outer ring—some curved hard wood vice clamps will be found necessary for shaping it.

Strictly speaking, the angle of the chord of the vane should be greater at the inner end than at the circumference, but a uniform angle of about 25 degrees (with the plane of motion) will give nearly as good results and is more easy of attainment.

If gearing be dispensed with, and the pump driven direct, the speed of the wheel should be as slow as possible; in this case an angle of about 40 degrees would be suitable.

The wheel is shown with the vanes set to revolve it counter-clockwise, in accordance with the invariable custom of the older millwrights; but as in the present case this might impart a tendency to turn the wheel into the wind, and therefore to counteract the effect of the governing arrangements, the reader is advised to reverse the direction of rotation. It will be noticed that care has been taken to reduce edge resistance to the lowest quantity, and if the wheel be built as shown, better results will be obtained than are possible with wooden arms and vanes.

The fact that the wheel is built up of galvanized material will not entirely ensure it against corrosion, as the cut edges will be unprotected; it ought therefore to be painted. If it be desired to retain the galvanized appearance, aluminium paint can be used. Before applying paint, however, the surface of the zinc had better be cleansed by going over it first with a weak solution of vinegar and then with clean water, and afterwards thoroughly drying it.

Pumps.—The pumping power of the mill will be somewhat a matter of experimenting with different lengths of pump stroke, as a good deal depends upon whether the mill is "well blown" or not, and the excellence, or otherwise, of the workmanship will also enter into the question; but the following table gives about what should

be expected, and also indicates the size of single-action pump suitable for a given lift when the gear ratio is 1 to 3.

Total Lift.	Gallons per Hour.	Bore of Pump.	Approximate Stroke.
25 feet.	100	2 in.	3½ in.
50 „	50	2 „	1¾ „
100 „	25	1½ „	1½ „

The power required for the above-mentioned duties is only a fraction of what the engine should be capable of developing in a good breeze; but an ample allowance has to be made for frictional and other losses. If too large a pump be fitted, the mill will not start in light winds.

A 2-in. bore "lift and force" "windmill" pump could be purchased for about 30s., and in the end this will probably be found the cheapest and most satisfactory plan to adopt. The pump is driven by a pin screwed into the side of the spur-wheel and secured by a lock nut. Three or four holes should be drilled and tapped at different distances from the centre of the wheel, in order that the length of stroke may be adjusted (Fig. 66, *d* and *e*). If the wheel have spokes, and these are too slight to admit of drilling, a clamp with a projecting pin could, no doubt, be devised, or a disc crank could be made out of a pipe flange.

If the pump be driven direct, without the intervention of gearing, an eccentric on the wind-wheel

shaft would make the best job ; but a direct drive is not recommended, as the pump would run so fast that it would have to be reduced to almost microscopic dimensions.

In any case the pump stroke will be so short, and the side swing so slight, that a jointed connecting rod is hardly required ; for all but the shortest strokes, however, it will be necessary to curve the upper part of the rod so that it shall clear the wind-wheel shaft.

Pump Rod.—A continuous wooden rod—say, 1 in. square, but thicker at the top end, so as to admit a brass bush to work on the crank pin—will, therefore, answer the double purpose of connecting and pump rods. The connection at the bottom end can be made by bolting it to the " bow " which is supplied with the pump; any intermediate joints that may be required can be made with 1-in. by ⅛-in. fish-plates, about 6 in. long.

If the pump be not more than 12 ft. below the crank pin, one guide will suffice. As the pump rod must revolve with the head, it will require to be thickened up to a circular section where it passes through the guide. The latter (shown at *z* in Fig. 65, *a*) should be made in halves and screwed or bolted to a bar running across the tower. The best lubricant for wooden rubbing surfaces is plumbago and soft soap.

In conclusion it may be pointed out that if the

mill be required for driving machinery, bevel gearing will be required to transmit the power from the head. A 5-foot mill is, of course, very small for any practical purpose, such as driving a lathe ; it would, however, drive a small dynamo of, say, 30 watts output, which would be quite sufficient for charging small accumulators.

A SMALL WIND MOTOR.

The foundation of the wind-wheel required for this is the front wheel of an old bicycle with front spindle and cones complete. To the rim of this are attached eight or a dozen vanes of stout sheet tin or zinc 8 in. long and 4 to 6 in. wide, lying at an angle of 30° to the plane of the rim. The vanes will be more efficient if curved to the arc of a circle of about the same radius as the wheel, the concave side facing the wind. Solder or rivet to the back of each vane a rib of strip iron $\frac{1}{8}$ in. thick, projecting $\frac{1}{4}$ in. beyond the tip and $1\frac{1}{2}$ in. at the other, where it is twisted and bent to make a bracket by which the vane is bolted to the centre line of the rim. When all the vanes are in position, the tips of the ribs and vanes, which should previously have been bored or notched, are connected together by rings of stout wire, soldered on at all contact points.

One of the spindle nuts—that which will be on the outside—is screwed hard up against its cone,

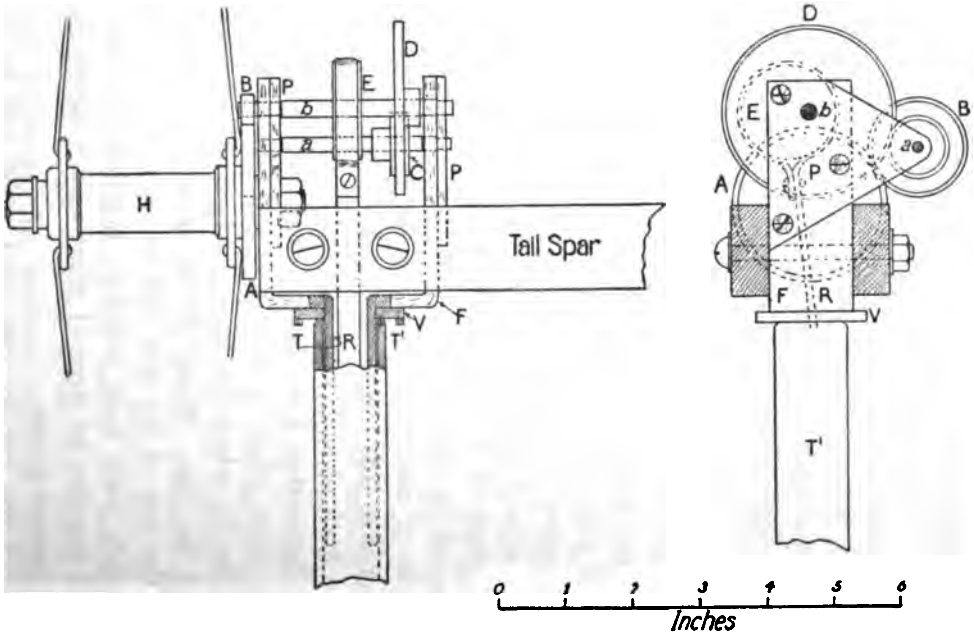

Fig. 68.—A small wind motor.

a thin washer being interposed (Fig. 68). The other end of the spindle passes through one arm of a stirrup, F, made out of ¼-in. iron, 1¼ in. wide, and a triangular plate, P, and is secured by a washer and nut on the inside.

The stirrup and a circular plate, V, are bored to take the end of an iron pipe, T, of ½-in. bore. The top of the hole in F is chamfered off, and the top of the pipe red-heated and expanded a little to fit the chamfer. The parts are then well cleaned and sweated together with solder, care being taken that T is square to the stirrup. Cut the pipe off 9 in. below V. A small ring soldered to the underside of V will prevent moisture working along to the pipe T, 4 feet long, in which T is able to revolve freely.

The left-hand diagram in Fig. 68 shows a side view and the right-hand a back view (as seen from the tail) of the gearing and supports. A is the rim and part of the spokes of a toothed wheel, attached at several points to the spokes of the cycle wheel. First fix A loosely and adjust it until it runs quite true when the wheel is revolved, without any wobble; then secure it. A drives a smaller cog, B, mounted on the same spindle, *a*, as a still smaller cog, C. This spindle revolves in two plates, P P, screwed to F. C drives a large cog, D, and an eccentric, E, which moves the eccentric rod, R, up and down and works a small pump at the foot of the mast supporting

the windmill. E can be made quickly out of a thick disc with two larger discs soldered to it. R is a piece of stout brass strip bent round E and closed with a screw.

The *tail spar* is a wooden bar, 1½ in. by 2½ in., 40 in. long, notched to fit the stirrup and tapered off towards the tail, a sheet of stout zinc or iron, 15 in. by 12 in., fitted into a saw cut. Two bolts clip the wings of the forked end tightly against the sides of the stirrup. The tail should approximately balance the wheel about the vertical pivot to avoid stressing the joint at the top of T.

Vanes, wheel, and tail should be given a good covering of paint to protect them from the weather before the windmill is placed on its support. This is a stout pole, to one side of which T is secured by a couple of straps in such a way that it projects sufficiently to prevent the vanes fouling. Three or four guys will make the pole quite steady. The circular pump rod attached to R works through eyes in the pole.

A wheel of this size will spin at great speed in a good wind, but is able to drive only a very small pump, which may be employed to fill a cistern for a garden fountain or do some other very light work of a similar character.

The wheel hub should be filled with a thick grease lubricant and the spindles and eccentric

supplied with the same. It is a simple matter to make a small metal hood to cover the working parts and attach it to the top side of the tailspar. The life of the bearings of spindle, *a*, will be greatly lengthened if they be extended by soldering plates to the sides of P P so as to distribute the pressure. A cord is attached to the tail to turn the motor out of the wind when it is not required to work.

Chapter XII.

HOW TO USE A BICYCLE FOR GENERATING ELECTRICITY.

MANY people would be glad of a simple means of generating current wherewith to charge accumulators for small lighting installations or for working model electric railways or other electrical apparatus of various kinds. A troublesome feature of accumulators is that they deteriorate rapidly if not kept well charged; and a great number are spoilt owing to the difficulty or trouble involved in getting them recharged when they need it.

Now, the propulsion of a bicycle along a road requires work to be done by the rider at the rate of, say, $\frac{1}{40}$ to $\frac{1}{8}$ horse power, according to circumstances. A strong head wind or a stiff hill may need an expenditure of energy approaching the larger figure. But let us assume that the rider exerts himself on the average to the extent of only $\frac{1}{25}$ h.p. This energy, if expended on generating electric current instead of on moving the bicycle, would give an electrical output of about 30 watts,

or, allowing for losses in conversion and by friction, of 20 watts. This is equal to a current flow of 2 ampères at 10 volts pressure, or of 5 ampères at 4 volts, or of 10 ampères at 2 volts, and so on; the watts divided by the ampères representing the volts, and the watts divided by volts the ampères. The nature of the winding of a dynamo decides whether the ampère or the volt factor predominates at a given speed.

It is a quite simple matter for a person handy with tools to rig up at a very moderate expense an apparatus which will enable him to drive a small direct-current dynamo by pedalling his machine—and incidentally keeping himself in condition and warming himself up nicely on a cold day. The general idea of the apparatus shown in Fig. 69 is that the rear wheel of the bicycle transmits power by friction to a roller mounted on a shaft which is attached to the armature shaft of the dynamo and drives it direct. It would be possible, of course, to avoid the use of a roller and let the pulley or disc on the dynamo spindle press against the tyre; and this method might be found satisfactory if the spindle had bearings of ample length. But inasmuch as the wheel is liable to wobble more or less, and as a roller, besides relieving the dynamo bearing, would permit the power to be applied to other purposes, we will assume a roller to be used.

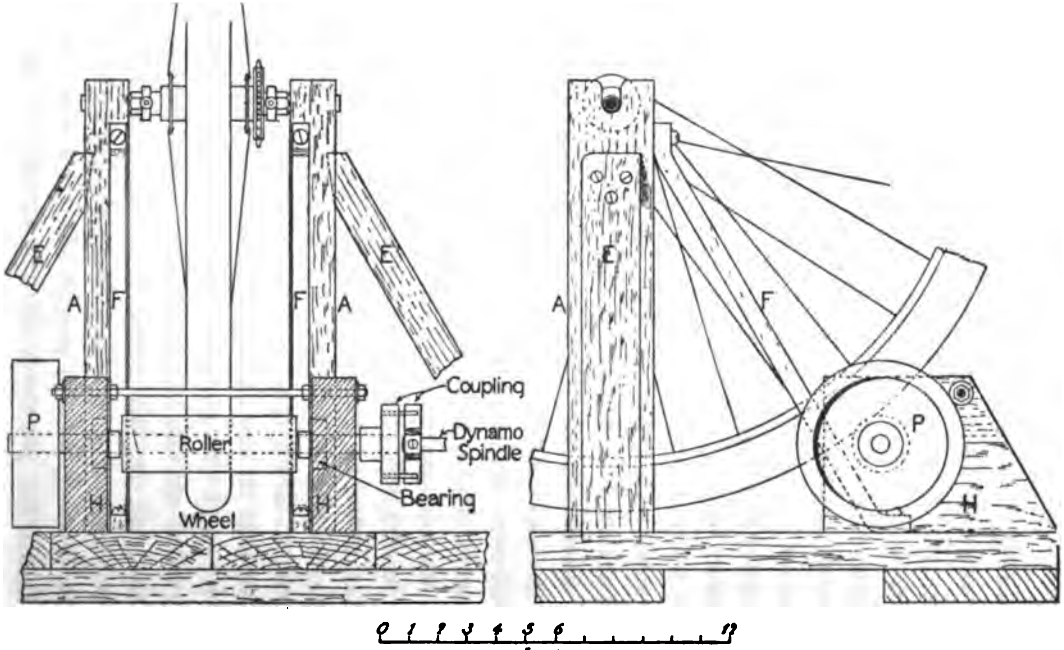

Fig. 69.—Bicycle driving a dynamo.

The first thing to do is to replace the nut on the right-hand end of the back wheel spindle by a second step, for a reason which will be evident immediately.

The next is to make a stand for the back wheel to keep the wheel clear of the ground and free to revolve. The general idea of it is shown in Fig. 69. A A are two uprights of 3″ × 1½″ wood with slots at the top in which the two steps rest. These uprights are stayed laterally by E E and fore-and-aft by F F, all screwed at their bottom ends to the base, B.

A shoe is needed to keep the front wheel from wobbling about. In its simplest form it is merely a board with two wing pieces, set tyre width apart, nailed to it; but an improvement is to fit a cross-piece extending outwards 18 inches to each side, from the ends of which steadying stays can be run to the top of the steering pillar, as the said stays will increase the stability of the machine considerably.

Now come the roller, by which power is transmitted from the back wheel to the dynamo, and its fittings. The shaft is a piece of polished steel rod ⅝ in. in diameter and 13½ in. long. Two ball-bearings of the Hoffman type, with internal revolving race, ball cage, and stationary external race, must be procured (at a cost of a few shillings each) to fit the shaft. The shaft is encased in a wooden roller, 2 in. in diameter. Bore a hole

of the right size as accurately as possible through the axis of a piece of wood 3 in. square and 6 in. long. Slip the block on to the shaft until it is central, and an inch from each end drill an ⅛-in. hole through it and the shaft. Drive into the holes pieces of ⅛-in. wire nails 1⅛ in. long until their ends are equidistant from the outside, and plug the holes. The spikes will bind the two parts together. If you possess a lathe, mount the shaft between centres and turn the wood down to size. If you have no lathe at command, mount the spindle on two temporary supports and work the wood away very carefully with a plane, using a bar of wood, kept parallel to the tube, as a guide, until the diameter is two inches from end to end. A little patience will give you a roller true enough for all practical purposes.

The ball-bearings should now be mounted in blocks, H H, 1½ in. thick, screwed to the base board. The inner faces must be perfectly square to the board and parallel to one another; this will be assisted by the rod and four nuts shown in the illustration. After marking out centres on these faces very carefully, to ensure their being at the same height above the board, and the same distance from the back edges, sink with a centre-bit holes of the same diameter as the outside of the stationary races to the depth of the races, and finish the boring with a ½-in. bit. The races are kept from falling

out by small plates screwed to the block. If the shaft be not a very tight fit in the bearings, small collars, provided with screws, will be needed on it inside the bearings to prevent end movement.

The position of the roller should be such as to cause the roller to press hard against the tyre when the cycle is in position, without indenting it unduly. The hardness of the tyre will of course to a great extent decide its grip on the roller.

The drive from the roller to the dynamo's armature spindle is direct. With a rigid connection exact alignment may be difficult to obtain. A coupling that will allow for a slight lack of truth is therefore advisable. This may take the form of a driving element mounted on the nearer end of the roller spindle and a driven element attached to the armature spindle. For the first make a thick wooden disc to clamp on to the spindle, with two spikes projecting from its outer face an inch from the centre. To the dynamo spindle is fitted a "follower" with wings to catch the spikes.

Assuming the cycle to be geared to 70 in., one revolution of the pedals will revolve the dynamo armature 35 times approximately; and at a tyre speed of 12 miles per hour the armature will turn 2,000 times per minute. If the cycle have a three-speed gear, the rider will be able to alter his pedalling speed while maintaining output.

Dynamos are designed to give a certain number of watts at a certain number of revolutions per minute. This speed should be ascertained, and if the roller be too large to give it at a reasonable pedalling rate, its diameter should be reduced, or the dynamo be driven off the pulley either by contact or belting.

For charging accumulators a cut-in and cut-out switch should be included in the connections between dynamo and accumulators. This automatically closes the circuit when the dynamo pressure exceeds that in the accumulators; and breaks it when the voltage sinks below equality, to prevent current flowing back through the dynamo.

A complete outfit would include a small voltmeter and an ammeter mounted on a board in view of the driver, to show the pressure and current flow. In Fig. 69 it will be seen that the spindle overhangs the bearings at the end away from the dynamo and carries a pulley, which both acts as a flywheel to keep the speed of the dynamo steady and is available for driving small machinery by belt after disconnecting the dynamo, arrangements for doing which easily can be incorporated in the coupling.

If the apparatus be meant only for driving machinery, the roller may well be of considerably larger diameter than 2 in., and one half of it be used as a pulley. This half may have a radius larger

than the rest, if a stepping-up of the speed be desirable.

In conclusion, we may observe that the legs are capable of a much greater continuous effort than the arms, and of driving more efficiently pumps, dairy plant, and other mechanisms usually worked with a handle.

Chapter XIII.

SAND YACHTS.

SAILING a wheeled "yacht" on long stretches of smooth, level sand is a very exhilarating pastime, as the speeds attainable are comparable to those of motoring, while the handling of the craft requires considerably more skill than the steering of a car.

The essentials of a successful sand yacht are that it should move very easily on a hard surface, and have wheels wide and large enough not to sink into the sand at soft places. Also, it should be kept as light as is consistent with strength, the live load being relied on to provide the ballast needed to overcome the upsetting forces of a high wind.

The yacht shown in the plan and elevation in Fig. 70 complies with these requirements. Two people, one in the seat to steer and the other standing or lying on the forepart of the platform to windward of the mast, will make a sufficient crew: though experience will show whether it can safely be given a heavier load where the going is good. If a third

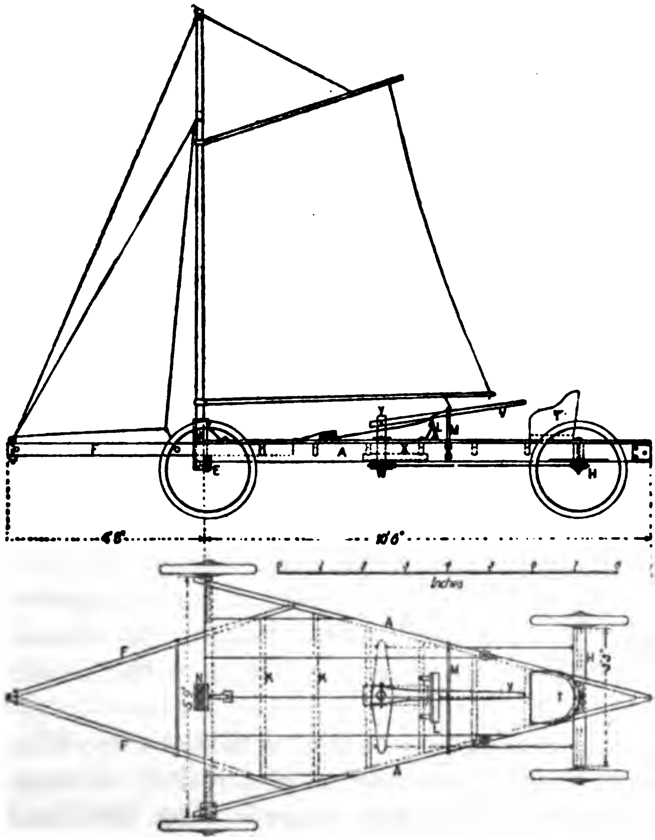

Fig. 70.—A sand yacht.

passenger be carried, he should be forward to relieve the steering wheels and help steady the yacht. In any case the instructions given can be modified to suit a craft of greater strength, capacity, and sail area.

The Framework.—This is a triangle made up of a front axle-tree, E, and two side beams, A A, and measures 10 ft. 6 in. in over-all length. E is of spruce, 4 by 2 in., with its larger dimension vertical, and 5 ft. 9 in. long. A A are two 11-ft. lengths of boarding, free from knots and "shakes," a full inch thick after planing and 6 in. deep, also set on edge. At their front ends they are notched to fit over E, care being taken to cut the notch to the correct bevel to make a good fit. The sides are clamped down to the axle-tree by four $\frac{3}{8}$-in. bolts lying in the vertical angles, and passing at each end through $\frac{1}{4}$-in. plates. As the clamps also serve to keep the axles in place, the bottom plates should be hollowed to fit the curve of the axles. It is important that the bolts should be quite in the corners and touch the parts; in fact, it is worth while grooving the surfaces slightly in the angles to give them a bite on the bolts.

The *jib-boom* of a boat is replaced by two bars, F F, of 4 by 1-in. stuff, passing over E, to which they are pinned and strapped with wire, and notched into A A at their rear ends. Their top edges must be flush with those of A A. The forward ends come together, bevelled to match, and are secured by a bolt and strap round the end. A long bolt 9 in. forward of E acts as "horse" for the jib sheet.

A A are connected by a series of cross bearers for the floor, spaced 15 in. apart, centre to centre. These are of floor boarding. The three aft bars are 3 in. deep; the others are tapered on the bottom edges from 5 in. at the centre to 4 in. at the ends, to save weight. The ends are stub-tenoned ½ in. into the inner faces of A A, over a depth of 2 in. Alongside of each should be fitted a tie of ¼-in. iron rod, with a head at one end and a nut and washer at the other, to prevent the sides spreading. Fit all the bearers and ties before A A are secured to E.

Over the rear axle-tree, H, is a larger cross-piece, 6 in. deep and 2 in. thick, bored for the bolt on which H pivots.

When the bearers and jib are in position, affix packing pieces, 1 in. thick, on edge, to the top of E, making a good fit between A F, A F, and F F where they cross E. Their top edges are in the same planes as those of A A.

The Floor.—This is made of ½-in. planed boards. If boards 12 in. wide be used, one 11-foot length will make the two outside pieces, and two lengths the two centre pieces, with enough over to cover the corners near the front wheels if desired. Screw the boards down securely to the bearers and A A. Nailing is much quicker, of course, but will be repented of if for any reason it be desired to make alterations or to dismantle the yacht for

packing, storing, or transport. The boards should be a trifle overlength to begin with, so that their sloping faces may overhang the edges of A A slightly and be planed off flush. Round off the top corners for comfort in handling.

Complete flooring may be dispensed with forward of the foot-rest, L, and its place be taken by narrow cross planks ¾ in. thick over the bearers, which will enable the second passenger to stand or lie on the frame. Some weight and cost will be saved at the expense of convenience in moving about.

Wheels and Axles.—Pneumatic-tyred wheels with tyres 2 in. or more in diameter and running on ball-bearings are ideal for the purpose. The larger the tyres, within reason, the better, provided that the wheels be not too heavy. Motor-cycle wheels are very preferable to those of an ordinary cycle, being much stronger and carrying larger tyres. The spindles will have to be specially made out of steel bar, at least ¾-in. thick, turned down and threaded to fit the cones, and should be 18 in. long over all. Making the spindles is a lathe job, and may have to be "put out." The spindles are bedded in grooves cut in the under side of the axle-trees and secured close to the wheels by the plates above and below, pinched together by bolts securing A A to E, as described already. The inboard ends are held firmly in position by straps screwed to the vertical faces of the axle-trees or by double

bolts and plates. Drill ¼-in. holes in the spindles for spikes to prevent endways movement. It is very important that the two spindles on the same axle-tree should be in line with one another, as otherwise the wheels will not be parallel and will drag, besides increasing the tyre wear. The fitting of the spindles will be done most conveniently before the axle-trees are attached to the other parts.

The rear axle-tree, H, is a piece of 4 by 2-in. stuff, 3½ ft. long, and lying flatwise. In order to reduce friction between it and the frame, the under side of the latter has strips of flat iron let into it and fastened with countersunk screws, and the top of H is similarly provided. If these metal pieces be kept well greased they will slide over one another easily enough.

Steering Apparatus.—This consists of a tiller, V, 3 ft. 9 in. long; a hardwood spindle, Y, 2½ in. in diameter; and a crossbar, W, tapering from 6 in. at the middle to 2 in. at the end. Stout metal pins are used to connect the parts. Y rotates in holes cut in the decking and in a board, X, screwed to two of the bearers. (If this part be undecked, X must be duplicated above the bearers.) The ends of W are connected with points on the rear axle-tree, the same distance from the pivot, by wire cables attached to eyebolts.

If the front axle of an old light motor car be

obtainable complete with wheels, it should be attached rigidly to the frame, and the wheels be worked by a lever in front or to the right of the seat. And if at the same time the back wheels and axles could be purchased, a very fine craft could be made, of a stronger type altogether.

Mast Socket.—This is built up out of four pieces of wood and bolted to the axle-tree, as well as stayed behind to the deck through plate washers on both sides of the last, or to a cross-piece.

Seat.—One of the shape shown is the most suitable, as it gives support sideways without hampering the arms. The back should be high enough to allow the steersman to sit back comfortably. The bottom is raised a few inches above the deck to give greater freedom to the legs.

The Horse.—M is an iron bar or tube, the horizontal portion of which is 9 in. above the deck, so that the pilot may get his feet in and out easily. The ends are flattened out to take bolts through the side members of the frame.

Sails.—White duck is a good material for sails. The mainsail shown is 6 ft. 9 in. at the bottom, 4 ft. 6 in. at the top, and 7 ft. 6 in. along the free edge. This will be large enough, in combination with the jib, to give a good speed. If more sail be carried it should be reefed down until some skill in handling the yacht has been attained. The sail area and speed are conditioned to a great

extent by the weight of the yacht and crew. The longer the front axle, the greater is the overturning effort required to cause a spill, and some yachts are therefore given very long front axles—up to 10 or 12 ft. But the craft described will be found to be wide enough for all ordinary purposes, and has the advantage of being movable along an ordinary road. When not required as a yacht, it could be used for the transport of hay or other light material and loads, a handle or pair of light shafts being attached to the rear axle.

Rigging.—This is of the usual type—forestay, shrouds, and backstays—made of thin wire cable, except the last, which, if used, are of thin rope working through small blocks.

A ONE-MAN YACHT.

The yacht illustrated by Fig. 71 is of simpler and cheaper construction than the one just described, but is designed to accommodate only one person.

It runs upon three bicycle wheels, preferably those of old motor cycles, the forks of which will also be required. All the wheels are set castor-wise—that is, with their axles vertically behind the fork stem. The two front forks must be fitted very tightly and pinned to prevent any twisting movement.

The frame is composed of an axle-tree, E, 6 ft.

long, of 3 by 4-in. stuff; a backbone, A, 5 by 3 in. and 10 ft. long; and four struts, F F, H H, of 3 by 3-in. wood. A is notched over E, and

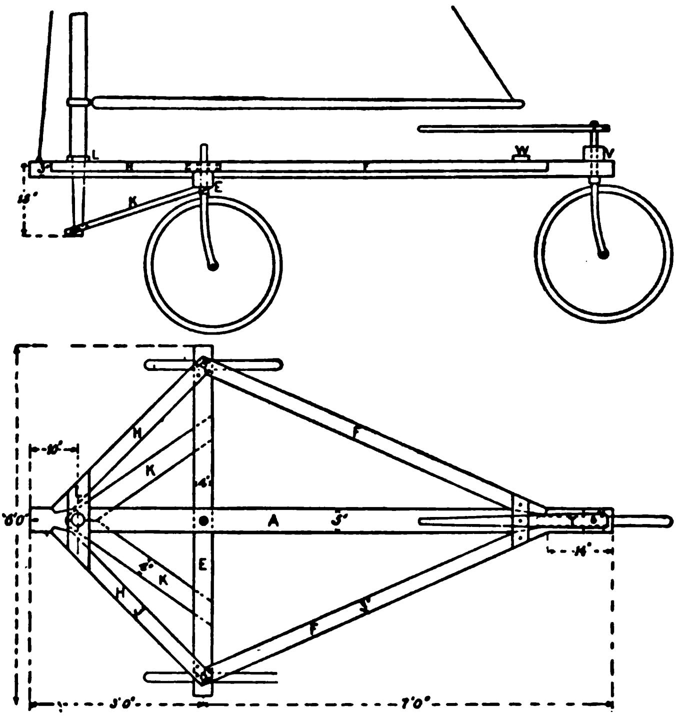

Fig. 71.—A light sand yacht.

secured to it by a bolt. At their A ends all four struts are sunk into the backbone as shown, to a vertical depth of 1 inch; the remaining inch fitting against the outer face of A. Or, to state it other-

wise, notches 1 in. deep vertically of the shape shown are cut in A and the strut ends made to fit. At their axle-tree ends they abut against each other and are secured by strong screws, and by straps round the outside. The fork holes should not be bored till they have been fitted. To prevent any possibility of their spreading, they are secured by wooden crossbars, L and W. The six parts make a frame which cannot possibly be deformed. Additional vertical strength may be given to A by continuing the bolt at the crossing point a foot downwards and connecting its end with points near the end of the frame by wire cables, tightened with a turn-buckle. A bolt of the kind used for wire fences would suit the purpose admirably. It will of course require two nuts and washers, one below E and the other above A. This "king-post" stiffening principle may be applied to F F, in which case the vertical thickness may be reduced from 2 in. to 1 in., and the weight of the frame be lessened by 7 or 8 pounds. If the maker care to go to the trouble, he can lighten the framework in other ways without materially reducing its strength. For instance, E and A may have their vertical faces hollowed out for $\frac{3}{4}$ in. on each side of the centre line to a depth of $\frac{1}{4}$ in., to reduce the beams to an I-section—but not at crossing points or near joints or the cycle forks.

The steering-wheel fork passes through the

backbone and a small 3-in. block screwed to the same. The tiller, T, is of 1-in. board tapered off to the handle end. The fork is held by a pin to the tiller. A bolt or a wrapping of wire between the fork hole and the end is advisable, to prevent splitting.

The mast is stepped through a hole cut in L and the backbone. Rigidity is given to it by two braces, K K, screwed to E, and held together at the apex by a hoop-iron strap round the outside. K K are shown 4 in. wide, but may be narrowed except at the ends, where good width is needed.

Should the yachtsman wish to be able to lie down on the frame, some kind of deck is required. For the sake of lightness this may be of stout canvas, held to the frame by eyelets and studs.

The sail is triangular, 7½ ft. at the foot and 12 ft. high.

A Caution.—Sand-yachters sometimes come to grief by running into soft places at high speed. This makes it advisable to take a preliminary run over the ground and note any bad places, with an eye to avoiding them or giving them a wide berth. When going about don't use the helm too hard and put undue stress on the front wheels.

Chapter XIV.

A MODEL GYROSCOPIC MONORAIL RAILWAY.

THIS very interesting apparatus is specially worthy of the reader's attention as a mechanical novelty of a high order.

The gyroscope in its simplest form is not a new invention, as it dates back a century or more. A specimen may be purchased at any good toy shop, at prices ranging from 1s. upwards. The gyroscopic top illustrated by Fig. 72 differs from an ordinary top in that the spinning element, *ab*, is supported at both ends of its axis in a frame, *cd*, by pivots, *e* and *f*, on one of which the top balances itself. The peculiarity of the apparatus is, that the framework may be stood on a string or pillar, and tilted over so that the top's axis is more or less parallel to the ground, without losing its balance.

This simple instrument has been adapted for steering a torpedo; steadying a vessel at sea, and steering it with a far greater accuracy than the magnetic compass allows; stabilizing an aeroplane; proving the rotation of the earth; and,

until the handle has reached a position nearly or quite at right angles to *nm*. If the apparatus declines, say, to the right, the handle will swing out in the one direction; whereas, if the tilt be to the left, the handle will swing out to the other.

Suppose, now, that the experiment is repeated, and that, as the apparatus tips and the handle swings out, the handle is given a slight push in the *same* direction as that in which it is moving. Contrary to expectation, this does not tend to upset the apparatus, but rights it, in accordance with the well-known gyroscopic law that the hurrying of the precession (that is, the tilting movement about the vertical axis, *cd*) will make the apparatus rise more vertically on its point or points of support.

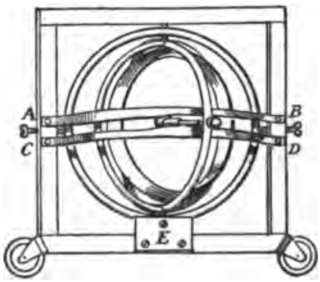

Fig. 74.—Simple type of monorail self-balancing apparatus.

It is obvious, therefore, that if the hurrying-on movement can be made automatic, the apparatus will become self-balancing; and, if provided with wheels, will be capable of running along a wire or rail so long as the propelling power and the spin of the gyroscope endure.

Just another point. The reader will no doubt at some time or other have amused himself by

throwing a hoop, ring, or wheel in front of him in a vertical plane, giving it a spin, so that the top always revolves away from him. When the hoop, etc., touches the ground, it bounds forward, propelled by its revolving momentum and the friction between it and the ground, added to its momentum as a whole. The same principle is applied to the controlling of our monorail car.

A VERY SIMPLE MODEL.

Fig. 74 illustrates the simplest possible type of model. The gyroscope disc revolves on a horizontal axis, pivoted on what we will now call an "inner" ring (corresponding to *cd* in Fig. 73). This ring is pivoted top and bottom (as in Fig. 73), but its support is now a second or "outer" ring, which is itself pivoted horizontally on the main wheeled frame. The gyroscope has, therefore, become "compound," with movement in all directions like a gimbal or "universal joint."

Now, if the apparatus tip away from one, the rear end of the disc axle will tend to travel to the right; and if it tilt towards one, it will tend to travel to the left, as we have already seen. At the same time, owing to the horizontal pivoting of the outer ring, it will tend to rise or fall.

The reader's attention is drawn to the strips AB, CD, one of which is above and the other below the axle. Should the spinning axle touch one of these

it will try to roll itself along it, as the ring rolled itself along the ground, the direction being to right or left, according to which of the two strips is touched.

The strips are shaped in a peculiar manner, as shown on a larger scale in Fig. 75. The inner edges are parallel, and set rather further apart than the thickness of the axle (seen end on, and indicated by a black circle). Furthermore, the left half of the edges is out of line with those of the right half to an extent rather less than the difference

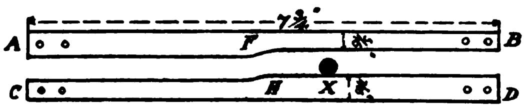

Fig. 75.—Contact planes for monorail car.

between the distance between the edges and the thickness of the axle.

A stop, E, on each side of the frame prevents the outer ring tilting laterally beyond very narrow limits. These limits are so arranged that the axle X (Fig. 75) touches CD only from H to D, and AB only from A to F. We may suppose X to be spinning in a clockwise direction, and, owing to the wheel-frame tilting, to precess towards the right. Immediately it passes H it comes into contact with HD, and hurries itself to the right. This hurrying-on of the precession causes the frame to come vertical again. Similarly, if the top were

processing to the left, owing to a tilt in the opposite direction, the axle would rub against FA and roll itself towards A, and the same righting movement would result.

The strips AB, CD, both pass inside the inner ring. The axle is ground down as shown in Fig. 76, to prevent it travelling too fast and far along the contact planes, and the pressure is very carefully regulated by the adjustable stops EE. The actual side swing allowed to the outer ring about its horizontal axis is very small—about $\frac{1}{16}$ to $\frac{1}{8}$ inch —but is absolutely necessary to enable the axis to touch and clear the contact edges where required.

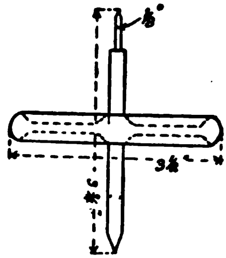
Fig. 76.—Spinning disc for monorail car.

A MORE ELABORATE MODEL.

The model just considered is able to maintain its balance when travelling straight ahead, but cannot take a curve in either direction. Any movement of the main frame on a vertical axis changes the relative positions of the planes of the framework and the gyroscopic disc, the latter not sharing in the movement. This brings the stabilizing control into action at the wrong time and in the wrong way, causing the model to upset.

If, however, we arrange the gyroscope to spin on

a *vertical* instead of a horizontal axis, we get a model capable of travelling round a curve in the direction opposite to that towards which the leading edge of the top is rotating. (This curious phenomenon is fully explained by the writer in a little book on the gyroscope, to which the reader is referred for further information.)*

A *perfect* gyroscopic monorail car with one gyroscope is, then, impossible. But if two gyroscopes of equal mass and size, spinning at equal rates and in opposite directions, be geared together in such a manner that their "precessions" are equal in amount, but in opposite directions, the difficulty is overcome. Such a model would necessarily be complicated and difficult to construct; so one should be content with a car which will travel either straight ahead or round and round a circle, or along a combination of the two. Any one who possesses a few tools, and some skill and patience, can make a car of this kind; so we proceed to give practical instructions as to its manufacture.

Figs. 77 and 78 are detailed diagrams. The gyroscope axle is vertical, the inner ring is pivoted horizontally, and the outer also horizontally. The inner ring pivots are at right angles to those of the outer ring, the movements of which they limit by contact with an adjustable stop projecting up-

* "The Gyroscope," by V. E. Johnson. (E. and F. N. Spon. 1s. 6d.)

wards from the frame on either side (Fig. 78, *b*). The gyroscope disc and inner ring are those of an ordinary gyroscopic top such as costs about 3s. 6d. at any good toy shop. The actual spinning disc is 3½ in. in diameter and weighs about 13¾ oz.

The Top.—The top having been procured, it must be made to balance properly and spin without vibration. If the disc be of lead, not brass, it probably will not be in perfect balance to start with. Oil the bearings and adjust them so that the disc runs freely without any looseness. Grip the inner ring in a vice, so that the top's axle is horizontal, and test whether the disc will remain motionless in any position. If one part of it persist in turning to the lowest point, drill small holes in it close to the rim, until the tendency is overcome. When good balance has been obtained, wind up and spin the disc fast, keeping the ring in the vice. Should the spinning not be accompanied by any obvious vibration, well and good. If, however, there is vibration, further tests for balance and corrections are necessary. A delicate test is obtainable by levelling two parallel metal straight-edges (real straightness is essential) and supporting the axle on these. Any want of balance will cause the top to roll till the heaviest part is lowest, there being practically no friction.

The value of the test, however, depends upon the points of the axle being exactly central; as, if

they are not, corrections as regards rolling balance would not apply to spinning balance.

The next thing to do is to turn or grind down the spindle, as shown in Fig. 76. The thin part when finished should be about $\frac{1}{8}$ in. in diameter and nearly $\frac{3}{4}$ in. long. The containing ring of a gyroscope (as bought) usually has a guard ring of thick wire attached to it in the plane of the disc,

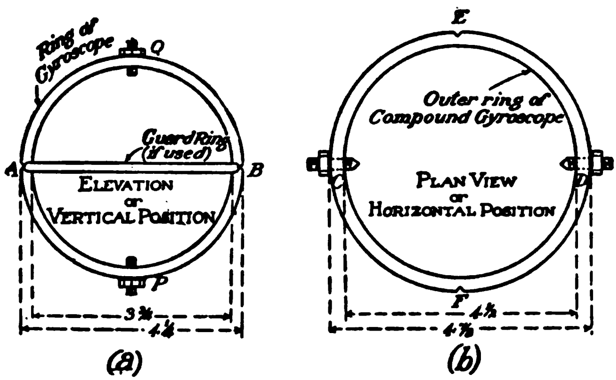

Fig. 77.—(*a*) inner and (*b*) outer rings of gyroscope.

to prevent the latter coming into contact with the floor or table should it fall. Though this is not necessary it may be left on, as it comes in useful for balancing purposes.

The disc axle runs in two pivots, Q and P (Fig. 77, *a*), each provided with a lock nut. At A and B, in a line at right angles to that joining Q and P, two nicks, A and B, are drilled to take the pivot points

on which this "inner" ring is balanced inside the "outer" ring.

This last should be, for lightness' sake, of iron or brass tubing. Its inside diameter is $\frac{1}{4}$ in. greater than the outer diameter of the inner ring. At C and D holes are drilled to take pointed bolts, secured by lock nuts (Fig. 77, *b*); and nicks are made at E and F for suspension pivots, passing through the framework (Fig. 78, *b*) of the car.

The balance of the disc and inner ring on the pins at A and B must now be obtained by means of the adjustable nuts on P and Q.

The Contact Planes.—The contact planes AB and CD (Fig. 75) are made of thin iron or brass strip $\frac{1}{16}$ in. or even less thick. The necessary curvature is given them by hammering them on what is intended to be their concave side. The end holes to take the screws or nuts which attach them to the framework should be a rather loose fit, to permit delicate final adjustment by tapping before the screw or nut is tightened up hard.

The Framework.—The wooden framework shown in plan in Fig. 78, *a*, and in elevation in Fig. 78, *b*, next demands attention. Poplar or American whitewood is a very suitable wood, being light, free from knots, and easy to work. The actual manner in which the framework is constructed is immaterial, so long as the leading dimensions are retained and the frame is *rigid*—a very important

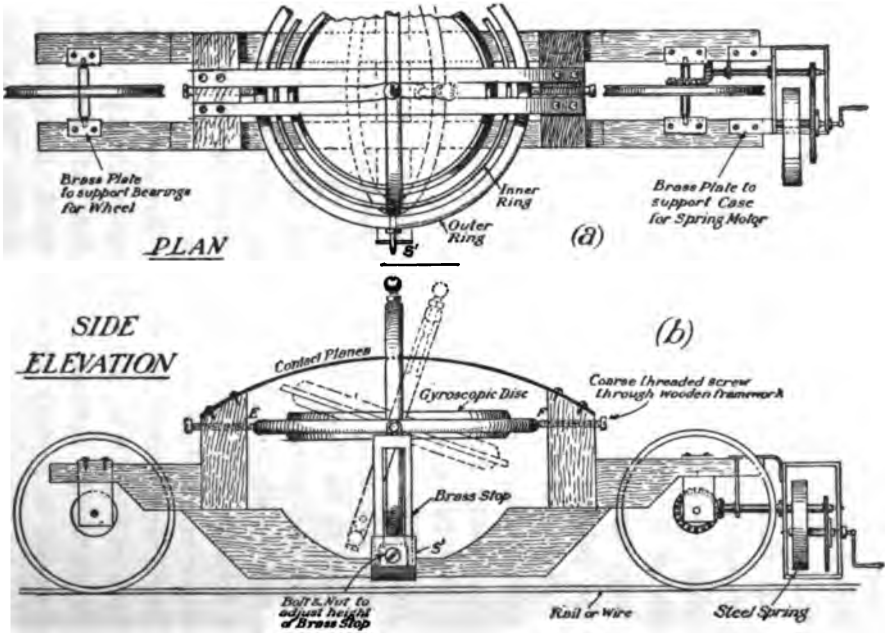

Fig. 78.—Monorail car. (*a*) Plan. (*b*) Side elevation. About ⅔ full size.

point. All joints and pieces should be carefully glued, no matter how otherwise fitted together. The reader should note that nut and bolt S^1 (Fig. 78, *a*) is the one which passes through the outer ring and on whose pin point the inner ring revolves, and not the S^1 of Fig. 78, *b*.

The size of the wheels need not be the same as indicated in the diagram, but, if smaller ones be used, the brass plates supporting the bearings must be longer. The lowest part of the wooden framework should not clear the rail *more than* ½ in., it being advantageous to keep the centre of gravity as low as possible. The wheels chosen should be light ones—light brass or even magnalium are very suitable—and of course be grooved.

The Motor to drive the model along the line or wire is a spring one, made from a cheap clock, all the works, etc., of which are removed save the spring, the winding-up handle, the cog-wheel on the same axis as the spring, and the first cog-wheel worked by it. The axle of the last is extended and a bevel gear-wheel attached to it in such a manner that it meshes with another similar bevel gear-wheel fitted on to the axle of the rail-wheel. By using a stronger spring and another large and small cog-wheel (on the same axis) a longer run could evidently be obtained.

As the gyroscope when spun well keeps going for a considerable time—perhaps for ten minutes—

the clockwork may require winding up several times for one spin of the gyroscope. In constructing the apparatus the greatest difficulty that the reader is likely to have is in the correct adjustment of the contact planes. When correctly adjusted, the spinning axle should just "chip" on and off, and no more. It is impossible to give any precise directions how to obtain this—the reader must perforce experiment.

The following points should, however, be carefully borne in mind: the spinning axle *must* be capable of touching one contact plane from H onwards towards D and *not* from H towards C, and similarly with respect to the other contact plane (Fig. 75). This is accomplished by means of the double adjustable stops, the tops of which are just below the pivots at C and D in the outer ring (Fig. 77).

The exact amount of pressure which the axle of the rotating gyroscope should exert on the contact planes must be found by test. If it be too great, the axle will travel too far along the contact plane, and overright the model; if the pressure be too light, the righting action will be insufficient.

Don't forget that in a monorail *everything* must be made to balance.

The complete model (Fig. 79) should, when placed upright on a stretched wire or single rail,

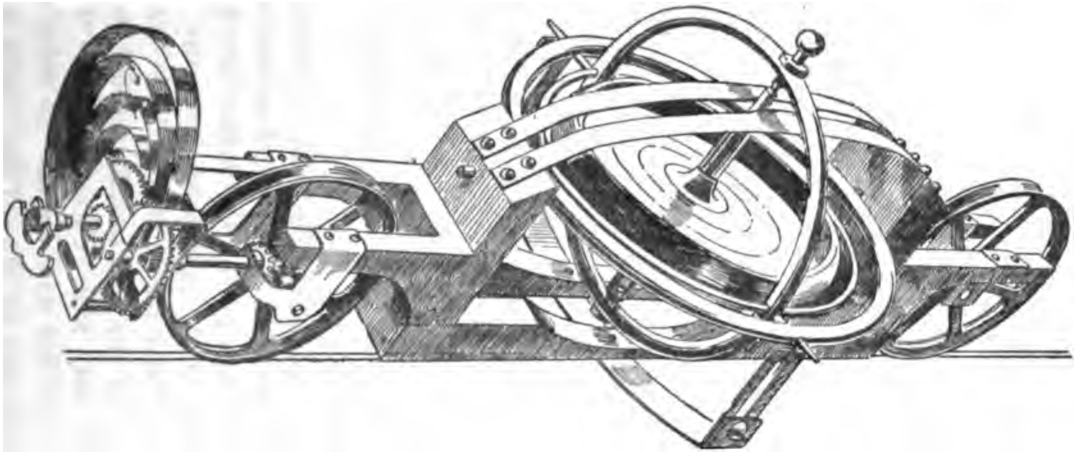

Fig. 79.—Perspective view of monorail self-balancing car.

tend to fall indifferently one way or the other. Before commencing to attempt to build the model, it is as well to practise spinning the top until one can get a really good spin on it. A thin, strong cord should be used, carefully and neatly wound on the axle, and pulled *steadily* off. Do not, to use a rowing phrase, attempt to "lug at the finish."

If the ring of the top be fixed in a vice, and about six feet of cord be carefully wound on it and pulled steadily off, a very good spin is obtained. If a second person hold the ring, the result is not quite so good. Spinning requires not brute strength but "knack" or skill, which can be in a great measure acquired by careful practice. A good spin is absolutely necessary for good results. The longest time that the writer has made a model such as that illustrated retain its equilibrium is twelve and a half minutes—that is, by the ordinary method of top-spinning.

Lines for monorail models can be constructed of any substance that a pulley wheel can run on. The substances employed by the writer have generally been fairly thick galvanized iron wire for the "straights" and ribbon iron for the "curves"—for which, by the bye, ordinary model locomotive rails serve very well. Curves must be "banked" just as if the line were double. In order that the model illustrated in Fig. 79 may travel around a

circular track, the wheels must obviously be not in the same plane—that is, the front one must be slightly twisted round a vertical axis or else able to swivel like a caster on a chair. If we desire the model to travel along a straight, take a curve, and then travel back along a second straight, the front wheel must be made to swivel.

The first care to be taken is to see that it can pass the curve steadily and freely.

A critical point of travel is when, after taking the curve, it reaches the straight and is proceeding along it.

The "stopping taking the curve" action is practically to some extent the same as that of making the car "take a curve" in the opposite direction—that is, in the same direction as that in which the top is spinning—and this tends to an upset. To avoid trouble the best plan is to make the straightening-out process fairly gradual. Skill in building models of a gyroscopic nature consists chiefly in so adjusting the controlling apparatus that the action of the gyroscope shall deviate as little as possible from its normal position.

In the model we have under consideration this position is a vertical one. Having given the disc a good spin in the right direction—that is, so that it runs in the proper direction already indicated along the contact planes—grasp the inner gyro-

scopic ring or the nut and bolt Q (Fig. 77, *a*) with one hand, and hold it steadily in its central or normal position. Place the model as nearly upright as possible on the line and let go. Be sure to release Q when the gyroscopic axis is at the middle—that is, the central position of the controlling planes.

At first you are sure to have upsets and accidents, so it is advisable to commence experimenting on a line or wire only a very small distance from the ground; or you may have a loop of cord passing crosswise under it, to catch it should it upset.

Covering-in.—Having constructed what one may term the skeleton model, you may like to enclose the same in some sort of body or car. The points to be remembered when doing this are: (1) leave every part of the mechanism easy of access; and (2) make the car as light as possible.

Aluminium foil for the body and the thinnest celluloid sheet for windows, etc., are about the best materials to use. As a matter of fact, in a simple model of this kind, where the rate of spin is not a very high one, every part of the model save the actual gyroscope is best constructed as light as possible. If your gyroscope rotate some five or six thousand times a minute instead of two thousand, the question of weight need not trouble you.

Instead of using a spring to drive the model along the line or wire, a small toy steam-engine can be fitted. Keep all the weight as low as possible with regard to both position and amount, and the model can be made to travel round and round a circular track (in the same direction) for quite five minutes after one good spin of the gyroscope. The diameter of the track may be quite small—6 feet or possibly less—but a diameter of some 15 feet is to be preferred.

Chapter XV.

MODEL STEAM TURBINES.

A MODEL steam turbine is a very interesting thing to make, and gives very satisfactory results if put together carefully.

It consists of the rotor, or revolving part, the nozzle from which the jet of steam emerges to strike against and drive the rotor round, and the bearings or supports for the rotor.

The Rotor.—In a very simple form of machine this may be a tooth-wheel from an old clock. It should be one of those which are fixed upon a spindle from $\frac{3}{8}$ in. to 1 in. long, according to the size of the wheel. The ends of this spindle are smaller than the rest, the ends of the larger part forming shoulders which greatly facilitate the mounting of the rotor in its bearings. Moreover, there is generally a small pinion upon the spindle which can be used to transmit the motion of the rotor to another tooth-wheel, and to reduce the speed to one suitable for driving small machines.

Bearings.—These can be of a very simple form.

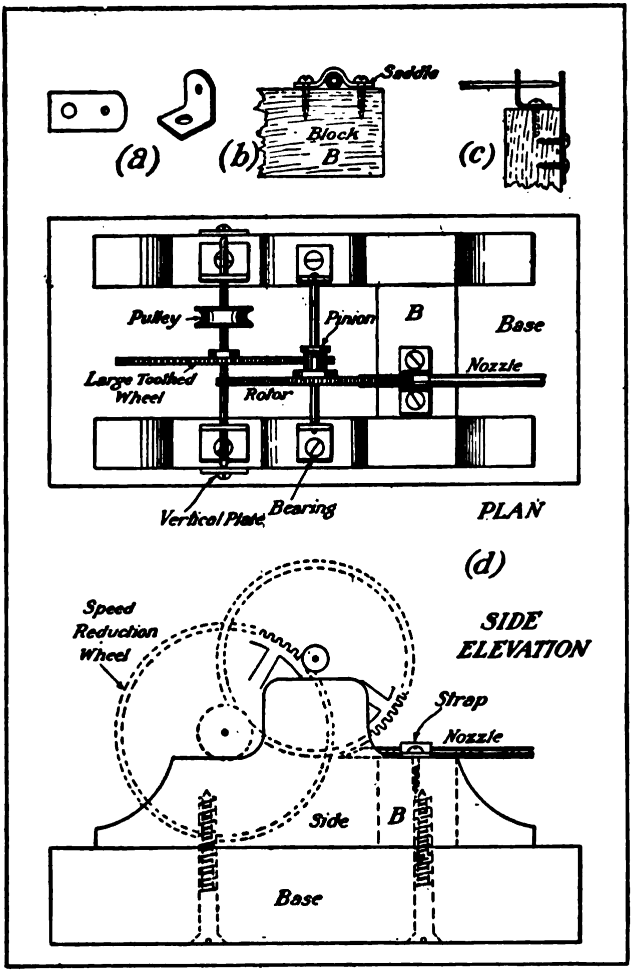

Fig. 80.—A clock-wheel turbine. (*a*) Supports for wheels. (*b*) Nozzle (in section) and saddle. (*c*) Bearing for reduction wheel. (*d*) Turbine in plan and side elevation (some details omitted). Half full size.

Take two small pieces of sheet metal, brass for preference, about twice the size given in Fig. 80, *a*, and drill in them four holes as shown. If you do not possess a very fine drill of the right kind, one can easily be made as follows :—A small piece of steel, such as half a very thick needle (a string needle, for example), should be heated at one end and permitted to cool slowly, so as to soften it. It should then be filed or ground on a stone to a sharp but short point something like that of a pencil. It is then reheated to a bright red heat, and cooled quickly by waving it about in the air. That will restore to it about the correct amount of hardness to render it a very useful punch for making holes in thin metal. Lay the metal upon a piece of hard wood or a block of lead, and drive the point of the punch gently through it with a few light touches of the hammer. When the hole has been made, insert the end of a fine broach (several of these should be on the bench of every model-maker), and a few turns will make the hole round and neat. The further you push the broach in, the larger the hole becomes. Any rough edges on the under side should be cleaned off carefully with a file.

Having thus perforated the two metal plates, bend them to an L-shape as shown in Fig. 80, *a*. The larger of the holes in each is for a screw to fix the bearing down upon a block of wood (to be

described presently), while the small hole in each admits an end of the spindle.

A structure to support these bearings is made out of two sides of nice wood $\frac{1}{2}$ in. thick, and a thicker piece forming the base.

Fig. 80, *d*, should now be consulted. It gives a side view of the complete machine. It is approximately to scale, but you may need to modify it to suit the size of the clock-wheel which you are able to procure. The two sides (exactly alike) are made of the $\frac{1}{2}$-in. wood, cut with a fretsaw or with chisel and gouge to the shape indicated. On each fix one of the bearings; then fix the sides upright upon the base, with the rotor in between the bearings. The distance apart of the sides must be carefully adjusted to suit the length of the rotor spindle. Attach them to the base with screws driven upwards.

At B put a small block of wood *in between* the sides, reaching just as high as the lowest point in the rotor.

Nozzle.—To make this, all that is needed is a piece of thin brass tube with a bore of about $\frac{1}{16}$ in., or even a little less. File one end off to a bevel as shown in Fig. 80, *d* (dotted), and then fix it on the block B by means of a small saddle of wood (Fig. 80, *b*).

The end of the nozzle should be as close as possible to the edge of the rotor without actually

touching. Blow through the nozzle and see that it drives the rotor well.

A second clock-wheel can be fixed upon bearings as shown so that it engages with the pinion on the rotor spindle. A wheel without a spindle, but bored for one, is most suitable in this case. A spindle must be made of a piece of straight steel wire of such a size as to fit tightly in the hole. If you cannot get a piece of exactly the desired thickness, get as near a fit as possible, and flatten the wire slightly at the spot where the wheel has to go by giving it a light blow with a hammer upon the anvil, so that it jams tightly in the hole in the wheel. In like manner fix a small grooved pulley on the same spindle, so that, by means of a small belt of thread, you can transmit the motion to some small machine to be driven. The bearings of this second shaft may be like those already described, but since the spindle has no shoulders, it will be necessary to provide two flat plates of brass beyond the bearings to prevent any endwise movement, as shown in Fig. 80, *c*.

The base and sides should be given two or three coats of dull black enamel, which, if the metal parts be kept bright, will give a nice finish to the machine. If carefully made and carefully kept, it will work well and look very attractive.

A MORE EFFICIENT MODEL.

The expert worker may desire to make something a little more elaborate than the above simple machine; or, having made this, he may like to try his hand on the other.

Rotor.—In this case the rotor is *made.* Procure a piece of sheet brass about $\frac{1}{8}$ in. thick and just over 3 in. square. Find the centre, mark it, and from it draw a circle 3 in. in diameter, and, from the same centre, another inside it, $2\frac{1}{2}$ in. in diameter. Then cut away all round the outer circle with a chisel until you have a disc approximately round, after which finish it off with a file until it is exactly circular. Drill a hole of $\frac{3}{16}$ in. diameter in the centre. If you possess a lathe, you can make the hole first and just skim up the edge in the lathe, as this will give you a truer disc than can possibly be made by hand. Still, with care you can make a very good one by hand-filing.

Divide the circumference of the circle into forty-eight equal parts, carefully drawing a radial line from the centre to each of the divisions. After that, attach the disc to a block of wood, by a screw through the central hole (Fig. 81, *c*), and proceed to file a slot, with the edge of a thin flat file, from the circumference down to the inner circle, along each of the radial lines.

These slots must not be at right angles to the

surface of the disc, but make an angle of about 60 degrees with it (Fig. 81, *b*). Holding the disc on a block of wood is to be preferred to a vice, because a line drawn on the wood will guide your eye in making these slanting slots.

Spindle.—This should be about 3 in. long, made of $\frac{3}{16}$ inch bright steel wire, which can be bought in short lengths perfectly round and perfectly straight. Cut a thread on one end of it for $\frac{5}{8}$ to $\frac{3}{4}$ in., and then screw down a small nut as far as it will go. Next, slip the disc on, and finally another nut. Placing this in a V-shaped groove in a block of wood, spin it round and see if the disc runs truly. If not, hold a piece of chalk in your left hand, while spinning the disc with your right, and let the chalk just touch the side of the disc. You will thus obtain a mark on the disc indicating which part of it comes over too far to the left. Slack back the outer nut, and place between the disc and the other a little packing, such as a scrap of tissue paper, until the disc is perfectly at right angles to the spindle. This process needs great care and patience, but is interesting.

Having trued the disc, find if it balances. If it does not, make it do so by filing a little metal off the ends of the teeth on the heavy side, or by boring a hole near the teeth. Ultimately you should get it to run perfectly smoothly, without any vibration.

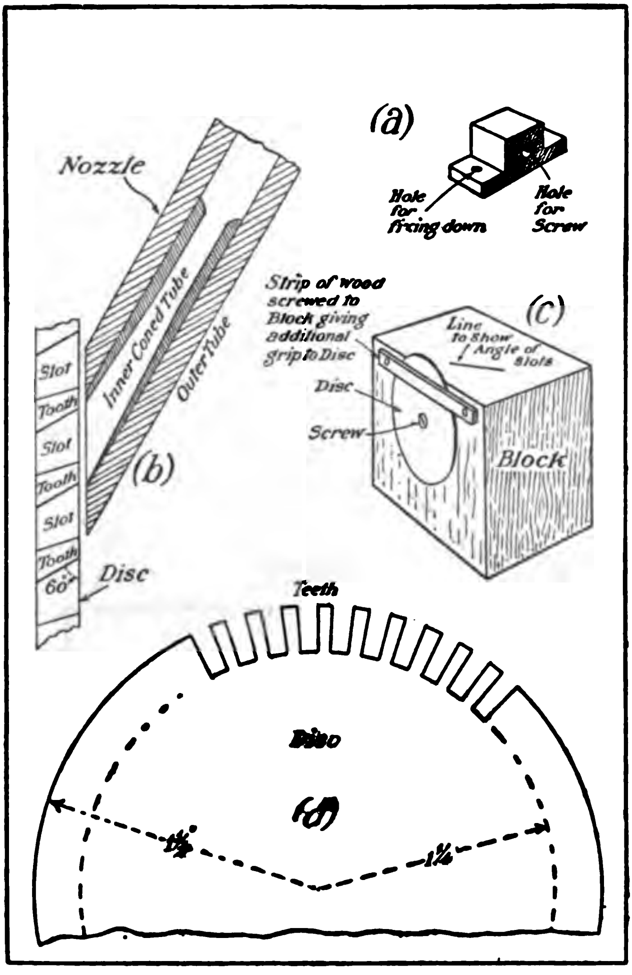

Fig. 81.—Details of steam turbine with vaned wheel. (*a*) Thrust block. (*b*) Section of nozzle. (*c*) Wheel disc mounted on block for filing. (*d*) Wheel with some vanes filed out.

Support.—This is cut from a block of wood to a shape shown in Fig. 82, *b*, and is mounted upon a thick, heavy block which forms the base.

Bearings.—These may well be a little more elaborate than those of the other model, but really only for appearance' sake, because those already

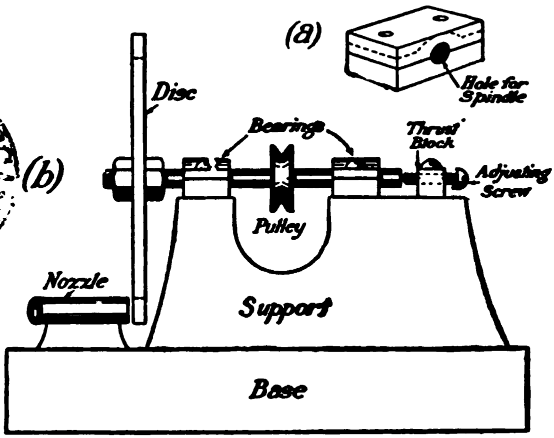

Fig. 82.—(*a*) Bearing for turbine. (*b*) End view of turbine: nozzle not shown.

described are the best of all bearings for practical purposes in small machines.

Get two pieces of brass, as shown in Fig. 82, *a*, drill two holes in each, bolt them together with two small bolts and nuts. Then drill a hole through them so that half the hole is in each (this is easy if each plate be first nicked across with a file to give the drill a "lead"), its diameter being just

enough to allow the spindle to turn in it easily. Take the two apart again, file the upper to the shape shown by a dotted line in Fig. 82, *a*. As an alternative one may use for the bearings short pieces of brass tube fitting the spindle closely, held in place by wooden saddles on top.

Since the steam will tend to force the disc away from it, a " thrust " bearing will also be necessary. This may consist of a pointed screw passing through a brass block the details of which will be seen quite plainly in Fig. 82, *b*. The advantage of this form of thrust bearing is that it is adjustable. By turning the screw, the distance between the disc and the nozzle can be adjusted to a nicety.

Nozzle.—This, shown in section in Fig. 81, *b*, consists of two brass tubes, one driven tightly inside the other, the orifice being then broached out to a taper. The steam issues through a fine " neck " into the tapering mouth, where it expands, and so finally strikes the disc with the maximum velocity.

The nozzle should be fixed upon a block of wood by means of a saddle, as in the other machine; but it will be noticed that in this case it is pointed, not at the circumference of the wheel, but at the side, near the circumference.

This machine is strong, and will work well under a good pressure of steam. It can be geared down by a clockwork train if the speed be found too high.

Chapter XVI.

AN ELECTRIC RAILWAY.

A Simple Electric Locomotive—Model Railway Electric Signalling.

A SIMPLE ELECTRIC LOCOMOTIVE.

IN Chapter XIII. of the companion volume to this, "Things to Make," is described the construction of a 2-in. gauge electric track, and of an electric locomotive which is similar to the one to be treated of here, except as regards the method of transmitting power from the motor to the wheels. In that case plain pinion and cog wheel transmission was used; in this a worm and worm-wheel, which has advantages, owing to the greater possibilities of gearing down, over the other in the matter of tractive power, though perhaps at the expense of speed.

The "bedplate" consists of a piece of $\frac{3}{16}$-in. hard wood measuring $6\frac{1}{2}$ by $3\frac{1}{2}$ in., stiffened by buffer beams at each end and a central cross beam. Driving wheel axles are 3 in. apart, centre to centre. (Fig. 83.)

The motor must be of the tripolar type to be

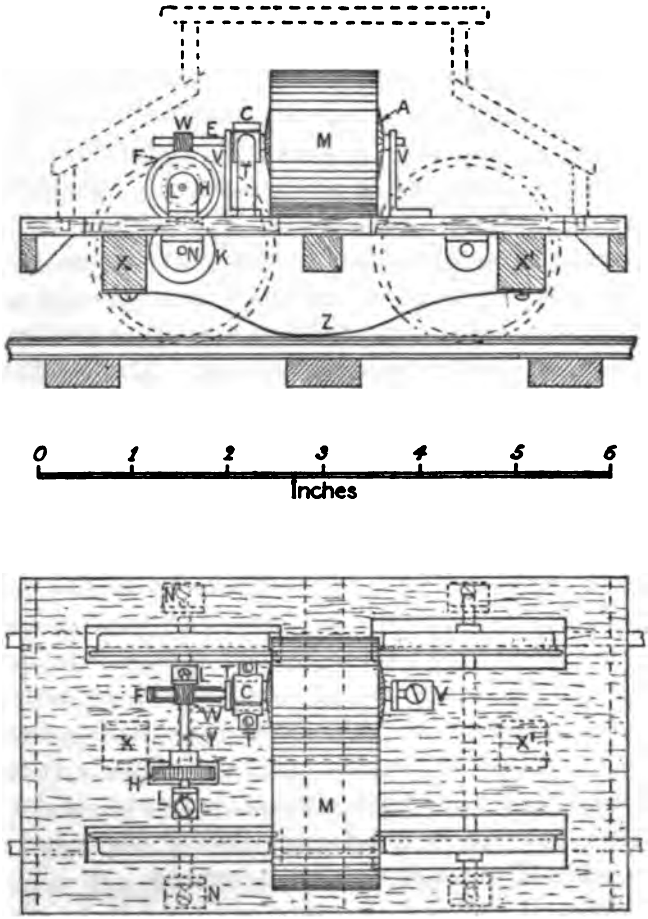

Fig. 83.—Side elevation and plan of electric locomotive.

self-starting, and should have a permanent magnet to be reversible without the use of complicated switches. The motor is placed crosswise on the bedplate with the tail of the magnet between the wheels on one side. A worm, W, mounted on the armature shaft, drives a worm-wheel, F, which is on the same shaft as a pinion, H, engaging with a pinion, K, of equal size, on one of the axles. To turn the wheels once, the motor must revolve as many times as there are teeth on F, so that a gearing-down of 1:20 is easily obtainable. This renders the machine an easy starter with a load. If the travelling speed be found to be too low, H should be replaced by a larger, and K by a smaller pinion, the combined radii of which are equal to those of the original wheels. A comparatively small increase in the number of teeth of the H wheel will, with the necessary reduction in the number of teeth in the other wheel, make a considerable difference in the speed. The handy mechanic will be able to devise a two-speed gear with the aid of two sets of pinions and a dog clutch, which holds one of the driving pinions fast while leaving the other free to revolve. This, however, is a refinement which may not be considered worth the trouble it involves.

The magnet and armature will need to be dismounted from the base of the original motor.*

* If a motor of the vertical type be obtained it can be screwed direct to the bedplate.

The magnet is strapped down to the bedplate and the armature spindle provided with suitable bearings of strip brass, V V, which will centre it correctly in the poles of the magnet. The worm and worm-wheel should preferably be bought from a model shop, but a makeshift can be contrived out of a clock pinion and a carpenter's screw, with threads of the same pitch as the wheel's teeth—though the attachment of the screw to the spindle so as to be truly in line with it is not a very simple business and requires a good deal of care.

The height of the spindle centre and the radius of the worm decide between them the distance of the centre of shaft, Y, above the bedplate, and the standards, L L, for Y must be bored after this has been ascertained carefully. Some adjustment of the worm is possible by tilting the magnet and armature slightly. This will, of course, involve a similar tilting of standards, V V, and the brushes, T T. The holes in brackets, N N, for the driving axle are so positioned that H and K shall mesh correctly. Any needed adjustment is made by countersinking into the bedplate or packing up, as the case may be.

The driving wheels have no side play, but the other two should be able to move ⅛ in. in either direction if the track be curved. The slots in the bedplate must be wide enough to allow for this movement.

Current is picked up from the insulated third

rail, midway between the running rails, by a strip of springy brass, Z, screwed firmly to block, X, and held to block, X, by a pin along which a slot allows it to move slightly in either direction.

The electrical connections are as follows: one armature brush is connected with the brackets, N N, of the driving wheel, the other with the X end of Z.

The locomotive is provided with a removable wooden cab of thin wood, kept in position on the bedplate by a couple of projecting pins at each end and a couple of small hooks and eyes. The top of the cab should be domed slightly laterally. The addition of two pairs of neat model buffers and coupling hooks will improve the appearance of the model. The side edges of the bedplate may be supported by strips of the same depth as the buffer beams, which will also serve to conceal the wheel brackets.

Automatic Reversing.—Reversing in the ordinary way is effected by means of a three-way switch which reverses the polarity of the rail circuit. If the track be a straight one, the locomotive may be provided with a switch which will automatically reverse the current when the locomotive approaches either end of the rails. The principle of such a switch, which may be affixed to the under side of the central cross-beam, is shown in Fig. 84. H is a small plate of compressed fibre or other insulating material, into which are sunk three small brass

contacts, A B A¹, flush with the surface, and $\frac{1}{8}$ or $\frac{3}{16}$ in. apart. C and D are two parallel brass strips with their centre lines halfway between the centres of the studs. They are pivoted near the tail end, which should be first bent towards the plate a little to make the strips tend to press against it at the other end. Where the strips sweep over the contacts they must be provided with small spherical studs—the heads of brass gimp tacks will

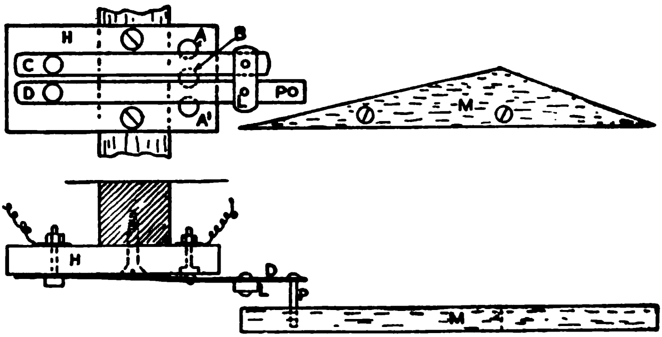

Fig. 84.—Automatic reversing switch for electric locomotive.

serve admirably—riveted on the back. A link, L, of insulating material makes them move together.

D, which must be somewhat longer than C, has a pin projecting from the side away from the plate. This pin strikes against a switch block, M, fixed to the track between the centre and a running rail, and shifts the bars laterally $\frac{3}{8}$ in. or so, as it slides along the inclined edge. The bars are thus moved from A and B to B and A¹, or

vice versa, according to the direction in which the engine is travelling.

H is screwed to the under side of the central transverse bar under the bedplate.

The connections are: pivots of C and D to the armature brushes, T T (Fig. 83), A A^1 to wheel brackets, B to centre rail.

There will, of course, be a switch block near each end of the track, one facing and the other turned away from the centre rail.

The P end of the bars should preferably point towards the driving wheels, where the lateral movement on the rails of the engine is least.

MODEL RAILWAY ELECTRIC SIGNALLING.

It is possible that many people who are interested in model railways may be glad to know of a quite interesting work—the equipment of a railway with electric signalling apparatus.

The signals about to be described are of the type used at Victoria Station (London), St. Enoch's (Glasgow), and many other places. In these the signal arm is not simply attached to a post, but is enclosed in a circular case, the front of which is plain glass, while the back is ground glass. Behind the latter a lamp is placed for use at night.

The Case.—To commence with, make a circular ring of sheet brass or copper, say, 2 in. in diameter and $\frac{5}{8}$ in. deep. This is an average size,

and the one which we will take here; but the worker will, of course, modify the dimensions, so that the signals may look in keeping with the rest of his apparatus.

To make this ring, get a piece of wood or other round object just the right size, measure its circumference exactly with string or thin wire, cut your strip of brass to that length, and then roll it round, coaxing it and filing it, if necessary, until a nice regular ring is obtained, the two ends of the strip butting together. Then solder on a short strip to cover the joint. The completed ring we will call the "case."

Three small distance-pieces of brass $\frac{5}{8}$ in. long and $\frac{3}{16}$ in. wide, bent up $\frac{1}{8}$ in. at each end, are soldered inside the case, as seen in Fig. 85, *c*. They will be, when bent, just about $\frac{3}{8}$ in. long, so that they can be placed with their ends just about $\frac{1}{8}$ in. from the edges of the case. The turned-over ends will therefore form ledges upon which can rest the two cover glasses. If you are an adept with the glazier's diamond, you can cut these glasses yourself; but in most cases it is advisable to buy them ready cut. A watch glass makes a good front glass, but costs a little more than plain glass cut from a sheet.

At this stage of the proceedings the ground glass may be fixed in with cement of any kind, such as seccotine, but the other must be left for a while.

It is now necessary to measure carefully to find what will be the space between the centres of the two glasses when the second one is put in. If all the distance-pieces have been carefully made to the same size, there will be little trouble in this. An ordinary brass pin is cut to a length slightly less than this distance to form the axle upon which the arm will rock, and it has to be supported by two small glass beads cemented to the inner surfaces of the glasses.

The arm itself can be made of a strip of thin tinplate cut from a tobacco tin or something of that sort. The axle is passed through a hole punched in the centre, and soldered carefully at right angles to the surface of the arm.

Having found two small glass beads of such a size that the axle will just fit easily in them, cement one to the centre of each glass. That done, and the cement set, drop one end of the axle into the bead on the ground glass, and slip the plain glass into position, with the bead upon it over the other end of the axle. This is a tiresome job sometimes, but with a little care and with a little luck it can be done quite easily.

Set the apparatus on its edge and you will see whether the arm is properly balanced and works easily in the beads. The balance must not be exact, but there must be a slight tendency for one end to go down. You will be very unlikely to get

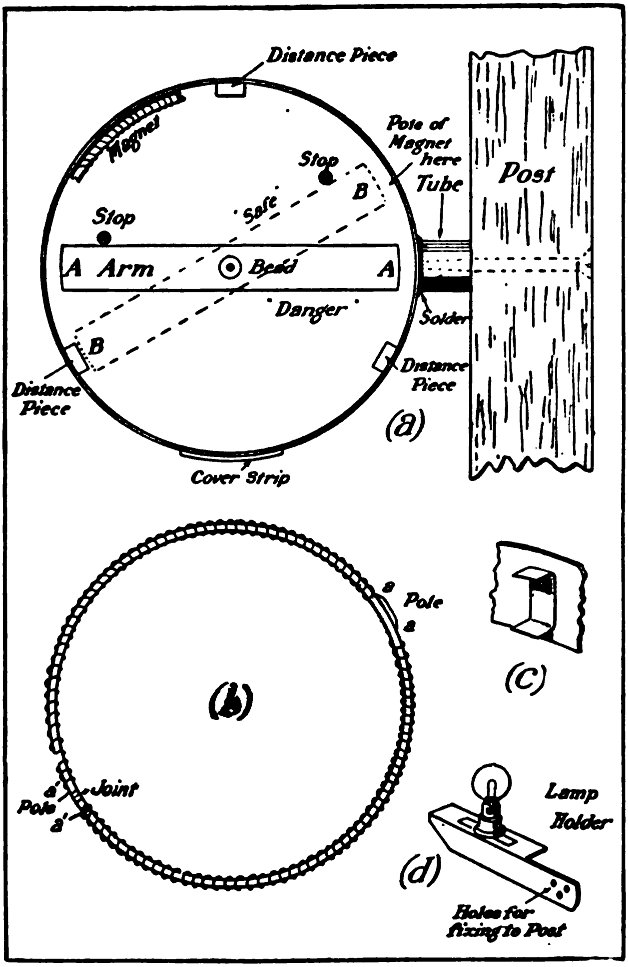

Fig. 85.—Details of electric signalling apparatus. (*a*) Signalling disc on post with arm A A in "danger" position. Position B B indicates "safe." (*b*) Diagram showing how magnet is wound. (*c*) Distance-piece. (*d*) Lamp-holder on bracket.

an exact balance, but if you have measured the centre carefully, you will probably find that there is only just enough "lopsidedness" to produce the desired effect. If one side goes down very decidedly, you must file a little off that end, until a state of "almost-balance" is attained.

Then, holding the arm with heavy side to the right, paint the front of it red. Red insulating varnish such as is used for electrical instruments is very suitable, and has the advantage of drying in a few moments.

So much for the mechanical part of the signal. We can now proceed to the electrical. This is very simple.

The Magnet.—We need a ring of soft iron, of such a size that it will go inside the case between the turned-up ends of the distance-pieces. A piece of soft iron wire about $\frac{1}{8}$ in. thick should be hammered out until it is $\frac{1}{4}$ in. wide, and as flat as possible. As this will tend to harden it, it should be put in the fire overnight, so that it is red hot for a while, afterwards cooling slowly as the fire goes out, to be rescued from the ashes next morning. This gradual cooling anneals it and makes it soft. It will need, after that treatment, to be cleaned with emery cloth. Cut off just the length required, and curve it as you did the brass ring. Then wind it with fine insulated copper wire of about No. 40 gauge in the manner shown in Fig. 85, *b*.

Of course, the turns will be close together, and not as represented in the diagram, since they have been shown far apart there merely for clearness' sake. Notice specially that each half of the ring is wound in a different direction from the other. To prevent the wire uncoiling between *a* and *a*, bind it in two places, as shown, with a couple of turns of silk thread smeared with cement of some sort.

The reason for this reversal of winding is that we want the two halves of the ring to form in effect two separate semicircular magnets, with the two north poles together and the two south poles together. These poles will be at the two parts which are bare of wire (between a and a and a^1 and a^1). The joint in the ring should be in the centre of one of these bare parts.

Having completed the winding of this double magnet, place it inside the case, between the ends of the distance-pieces, leading the ends of the wires out through a small hole in the casing. The magnet must be so placed that the poles are at the points where you wish the ends of the arm to be when it is in the *safety* position—that is, sloping from the post side towards the other at an angle of about 40 degrees to the horizontal.

If the iron ring be made a shade too large, so that it has to be compressed to get it in, it will need no fixing, but will remain in position of its own accord.

So when it has been inserted only one thing remains to be done before placing the front glass in position finally and fixing it with cement—namely, to cement to the ground glass two small *brass* (not iron) pins, as indicated in Fig. 85, *a*. They must be just under $\frac{3}{8}$ in. long, and their heads be filed quite flat, so that they will abut squarely on the ground glass. They form the "stops" to limit the movement of the arm.

Action of Signal.—If, now, the signal be placed on edge, the right-hand end of the arm, descending because of its weight, will bring the left-hand end up against the left-hand stop, and there it will remain at the horizontal or "danger" position. Then connect the ends of the wire to a battery, and the ends of the arms will be drawn to the poles of the magnet, the right hand upward and the left downward, until the movement is arrested by the other stop. So long as the current continues to flow, the arm will remain in this position. As soon as the current is interrupted, whether by accident or design, the arm will return to "danger," as every well-regulated signal arm should do.

It is safe to say that if a signal such as this be carefully made and treated with ordinary care in usage, it will always work well and will never get out of order.

Attachment to Post.—To attach it to a post, solder a short piece of brass tube to the outer case ;

drive a piece of wood into the open end of the tube, and pass a brass screw through the post and into the wood. Let the hole through which the wires emerge be close to the tube; lead the wires to and down the post; or, if you care to go to the trouble, you may drill a hole right up the post and carry the wires down through it out of sight.

Fig. 85, *d*, shows how a bracket can be made out of sheet brass, to fix to the post for the purpose of carrying an electric light behind the signal. The lamp-holder is seen soldered to the bracket, ready to take a miniature incandescent electric lamp. There is a little screw on the holder, to which one of the lighting wires should be attached, while the other should be connected to one of the screws holding the bracket to the post.

The bracket should be fixed so that the bulb comes approximately in the centre of the case. A small shade can easily be made out of sheet metal to cover the lamp, being fixed either to the bracket or to the back of the case. If the back of the shade be made of tinplate, it can be polished, and will then act as a reflector. Full particulars as to sizes cannot be given, because, as already pointed out, the signal must be proportionate to the rolling stock; and, moreover, the lamps and holders obtainable are not all of exactly the same size. A little judicious scheming will, however, enable the worker to modify and adapt these

directions to the circumstances of his particular case.

Signal-case and lamp-cover look smart if nicely blacked, or some of the brass parts may be left bright.

Switch-box.—The enthusiast will no doubt make

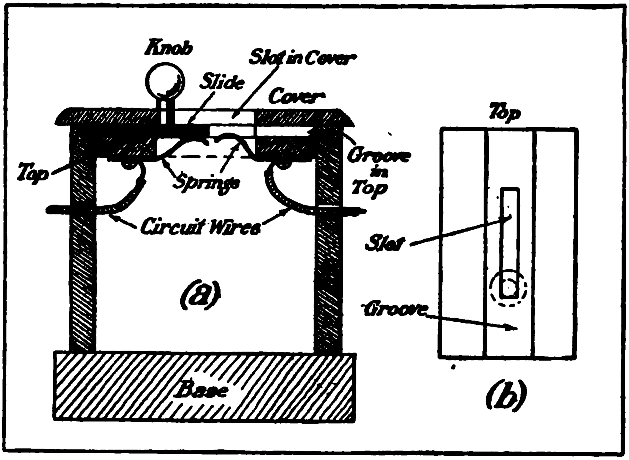

Fig. 86.—Switch box for electric signalling. (*a*) Sectional side view. (*b*) Top of box.

several of these signals, and will therefore need a set of levers by which they can be operated at will. Fig. 86 shows such an arrangement.

Construct a small chest of wood, with a stout, heavy base, thin sides, and thick top. Across the top, but not through the sides, cut a groove ½ in. wide and ½ in. deep, and in the centre of the groove

cut a slot right through the wood, as shown in Fig. 86, *b*.

A piece of brass is then made to slide in the groove, not tightly, but with as little shake as possible, and two springs are fixed to the under side so as to curve upwards through the slot, in such a way that they may press upon the slide. One presses upon it always, the other only when the slide is moved into a certain position.

A thin wood cover screwed down neatly on to the top holds the slide in place. Through a slot in this cover projects a little knob, by which the slide can be moved to and fro. In the position shown in Fig. 86, *a*, the slide makes contact with one spring only, and the electric circuit is broken; if it be pushed to the right as far as the slot will allow it to go, the slide will make contact with both springs, and the circuit be completed.

The wire from the battery is connected with one of the springs; that leading direct to the signal with the other. When the knob is pushed to the left, the signal is horizontal ("danger"); when to the right, the signal is down ("safety").

Any desired number of grooves and slides can be made, side by side, according to the number of signals to be controlled. All connections for the wires can be made inside the chest, and carried out in a bundle through a hole in the base or at one end.

A switch of any convenient type can be made and fixed, if desired, at the end of the chest for turning on the lights to the signal lamps.

If further realism be required, this "controlling frame" can be built into a little cabin with roof and glass windows, the back of the cabin being left out so that you can get your hand in to work the "levers."

Chapter XVII.

ELECTRIC MOTORS.

An Electric Wheel—A very simple Motor—An Induction Motor—An Electric Beam Engine.

AN ELECTRIC WHEEL.

THE very simple and easily made little apparatus illustrated by Fig. 87 is known as Barlow's Wheel. It proves in an interesting way the physical fact that if current be passed through a movable conductor in a magnetic field the conductor will tend to move across the field.

The conductor in this case takes the form of a 16-pointed wheel, 2 in. in diameter, cut out of a piece of thin sheet copper. Make a dent at the centre from which the marking circle is described, and be careful that the tips of all the spokes of the finished wheel are the same distance from it, as the success of the experiment depends largely upon this.

A good-sized *permanent* horseshoe magnet, M, is required, the poles of which are close together. This is clamped to a base board by a wooden crossbar, A, and a screw; the poles lying each side of

a groove ⅛ in. deep, and an inch or so long, cut in the surface of the wood.

The wheel is mounted on a spindle of steel wire sharpened at both ends, and must be arranged to

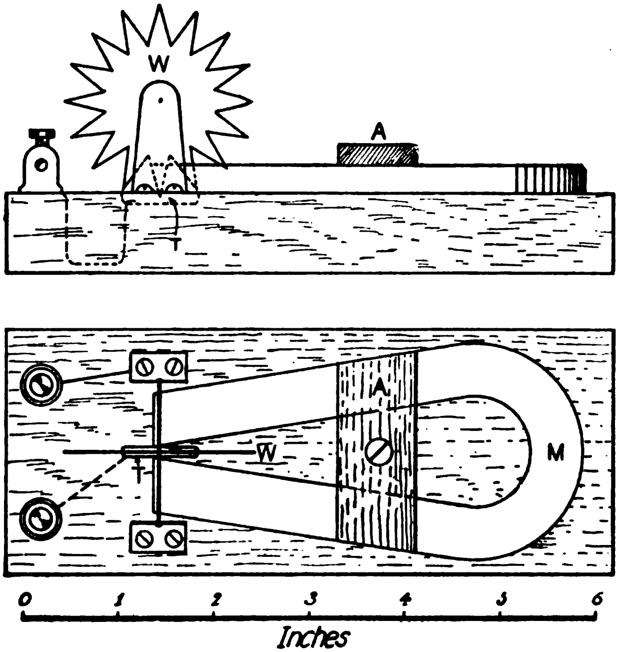

Fig. 87.—Barlow's wheel.

run quite true. To support the spindle prepare two small standards of thin brass, with turned-out ends, which are held to the base by small screws. The length of the spindle must be sufficient for the supports to clear the ends of the magnet.

Two dents are now made in the standards—which for the purpose should be backed by hard wood or lead—with a fine but not sharp-pointed instrument, care being taken that the metal is not penetrated. The height of the dents must be such that the wheel when mounted in position, with the spindle ends in the dents, just dips into the trough between the poles.

One of the standards is connected with a binding-post on the board; and from another post a wire passes through holes in the base up into the trough, its end being turned over and driven down into the bottom. Plug the hole through which the wire enters with wax or some other solid substance.

The trough is now filled with mercury, so that when the wheel is revolved the tip of every spoke may dip into it. The two binding-posts are then connected up with the terminals of a bichromate or Leclanché cell; and if everything be in order the wheel will begin to revolve and continue to do so as long as current flows. Each spoke, on touching the mercury, completes the circuit and becomes a conductor, round which is a magnetic field at right angles to the field of the magnet. The spoke therefore moves—its direction of movement being determined by the direction in which the battery current flows—out of the magnet's field.

If the magnet's poles be rather wide apart, procure two small pieces of iron or steel, arrange

them parallel to and on each side of the trough, and clamp the magnet down on the top of them. They will act as extensions of the poles and improve the efficiency of the motor.

A VERY SIMPLE ELECTRIC MOTOR.

For this motor is required an electro magnet such as is used in electric bells. The centres of the cores should be 1½ in. apart. This may require the removal of the coils from the yoke and their remounting on a longer yoke-piece. (Y in Fig. 88.)

Fig. 88, *a*, is a side view of the motor. M is the magnet, laid on its side, with the bobbins clamped down against a block, F, hollowed to fit them, by a screw passing through a plate H and F into the wooden base. F must be of such a height that the centres of the cores lie about 2⅛ in. above the base, and the screw be somewhat nearer one bobbin than the other, to allow room for the spindle.

A four-armed armature, A, which is seen in plan in (*b*), is cut from an iron disc 2 in. in diameter and ⅛ in. thick. A fine-toothed fretsaw may be used for the cutting, which should be done slightly outside the lines to allow for finishing up with a flat file. The arms are ⅜ in. wide. A four-armed contact-maker, S (see Fig. 88, *c*), is sawn out of a brass disc ⅝ in. in diameter.

Holes are bored in the centres of A and S for the spindle, a piece of $\frac{1}{8}$-in. steel wire (part of a knitting needle will serve excellently). The spindle should be fined down at the ends to fit holes in the yoke, Y (midway between the two magnet core centres), and in support, K. The last is held down

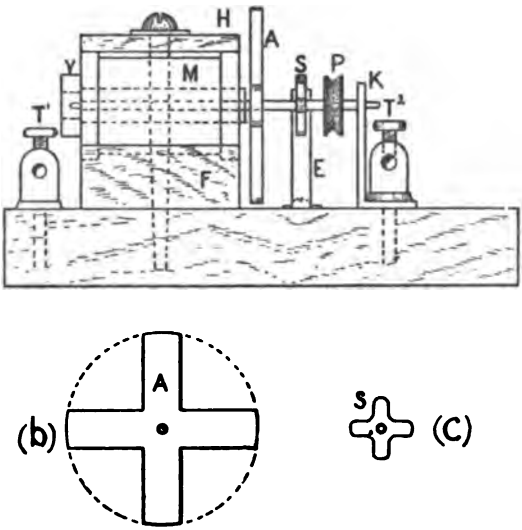

Fig. 88.—A simple electric motor.

to the base by a binding-post, T^2. E is a piece of thin springy brass or clock spring, turned out at the bottom.

Solder A to the shaft in such a position that it just clears the magnet poles; and take care to get it as square to the shaft as possible, so that it

shall not wobble perceptibly. This operation can be done best when the spindle is in position and the armature on it. If the hole be a slack fit, close it slightly by hammering the metal round it until the armature gets a fair grip when pushed on. Revolve the armature and adjust it until the arms run true. Then apply the solder.

The exact adjustment of S will involve some experimenting after the electric connections have been made—namely, T^1 to one end of magnet-windings; other end of magnet-windings to E. The terminals T^1 and T^2 are connected with the battery supplying current to the motor. Every time an arm of S touches E, the magnet will be energized and draw towards its poles the two arms of A that are nearest them. The arms of S should therefore be roughly in line with those of A; making contact with E when a pair of arms approach to within $\frac{1}{8}$ in. of the pole-pieces, and breaking it when the centre lines of the arms come over the centres of the pole-pieces. Tests will show which position gives the quickest running.

A small pulley, P, may be fitted to transmit power through a band of elastic to some easily-driven model (for instance, the pump described on pp. 319–322), the pulley on which should be several times larger than P.

The armature should be balanced very accurately, or the shaft will vibrate at high speeds. Its balance

may be tested by resting the shaft on two carefully-levelled straight-edges, and any lack of truth be corrected by filing a little off the arm which persists in assuming the lowest position.

Instead of a star-shaped armature cut from the solid may be used a brass disc with four iron blocks soldered to it at intervals of 90°. The running of the motor will be improved if the number of blocks be increased to 6 or 8, the contact star of course being given a corresponding number of arms.

AN INDUCTION MOTOR.

The induction type of electric motor, although largely used commercially, is little known to the model maker. Yet it is very suitable for amateur manufacture, since the commutator, so troublesome a part of the ordinary motor, is absent.

The machine which we are about to describe is shown in its main features in Fig. 89. The base is of wood, and upon it stand two blocks, also of wood. On the top of each of these last is one of the field-magnet coils. Stretching between these two coils, one under and one over them, are two curved pieces of hoop iron, the "yokes," the curves in which enclose a circular space inside which turns the armature or revolving part. The armature is fixed upon a spindle the ends whereof run in bearings, which, for the sake of simplicity, are not shown in this diagram.

In working, current circulates through the field-magnet coils, and since it is (as we shall see presently) intermittent in character, it acts upon the wires in the armature just as one winding of an induction coil acts upon the other. That is to say, it induces currents in the armature wires, and by so doing converts the armature into a magnet.

A motor of this kind will not start itself, but if it be given a start the induced currents in the armature lag behind those in the field-magnet coil, causing attraction and repulsion to take place between parts of the armature and parts of the field magnets in such manner that the armature is kept in constant rotation. The motor will work in either direction, according to which way it is started.

The armature is best made of steel stampings, which can be bought for the purpose ready made to shape from dealers in electrical sundries. These are discs of thin sheet iron. A convenient size is 3-in. diameter, with a ½-in. hole in the centre. Around the edge are cut twelve slots, as shown in Fig. 89, to accommodate the wires. About two dozen of these discs are needed.

Field Magnets.—In actual manufacture it will be more convenient to begin with the armature, but in description the field magnets naturally come first. The wooden base and blocks need little description. The two yokes are of stout hoop iron,

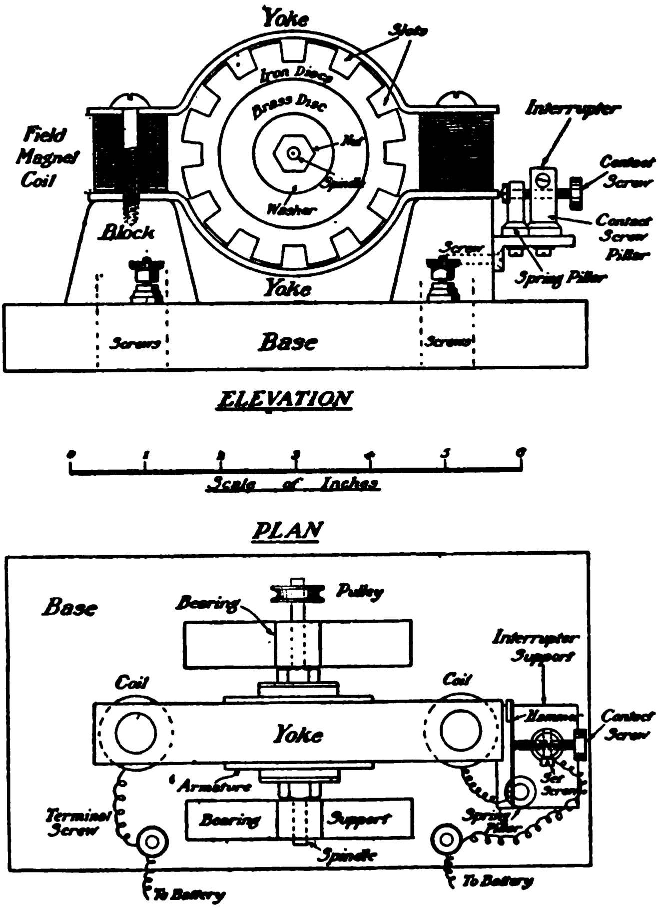

Fig. 89.—Side view and plan of induction motor (some details omitted).

obtainable from any good ironmonger. If you have not the means of drilling holes in iron, it is best to get the ironmonger to drill for you one hole in each end of each, taking the greatest possible care that the holes are exactly the same distance apart in both. By careful hammering, curve them as shown.

Next, two little ferrules must be made out of iron pipe ¼-in. bore and 1 in. long. These will form "distance-pieces" between the ends of the curved strips, and will also constitute the cores of the coils.

Having made these four items, place them together and see if the space will just accommodate the armature and allow it to turn without touching. It is of the *utmost importance* that the gap between the yokes and the armature shall be as small as possible.

Having got these adjustments right, fix the four parts in position by means of two stout carpenter's screws, passing right down well into the blocks.

Here another word of caution may well be added. See that the ends of the distance-pieces are smooth and clean, and that they fit closely against the ends of the yokes, which should also be bright and clean.

The Armature.—A sectional view of this is to be seen in Fig. 90. For the spindle get a round-headed ¼-in. Whitworth screw, 4 in. long, from an

ironmonger, together with two nuts to fit it. Cut off the head with a file or a hack-saw.

Next cut out sufficient discs of cardboard or thick paper to make up two thicknesses of ⅛ in. They must be exactly like the iron discs, except that they are ⅛ in. less in diameter. Then make a pile of six iron discs, sticking them carefully together with shellac varnish (varnish them sep-

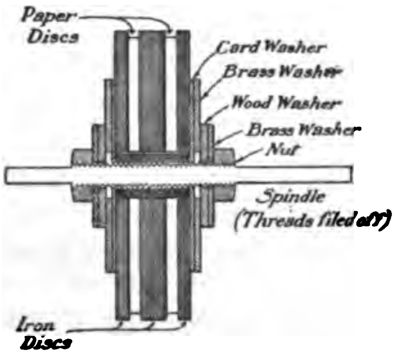

Fig. 90.—Section of armature.

arately, let them get nearly dry, and then press them together). Upon these stick paper discs to the thickness of ⅛ in., then add a dozen discs of iron, another ⅛ in. of paper discs, and finally the remaining half-dozen iron discs.

As you put these together it will be a great help to have a piece of ⅛-in. round iron or something similar to form a temporary spindle, and ensure all the discs being concentric. The varnish is

intended primarily to act as insulation between the discs, but it also serves to bind them together. When the drum is finished, it should be perfectly round and well-balanced, with twelve slots round its edge, and with two grooves running all round it circumferentially. These grooves are formed by the paper discs; their function is to accommodate thread for binding down the wires which will be placed in the slots.

We next require two discs of stout cardboard, 2 in. in diameter, with a ¼-in. hole in the centre; and two more of stout sheet brass of the same size, but with a ½-in. central hole.

Paint the card discs all over thoroughly with varnish, and stick one of them concentrically to each of the brass discs, the varnish serving as the cement.

Now take the spindle and the drum. Bind round the first a strip of hard but not too thick paper, as wide as the drum is thick. This will form a sleeve or bush upon the spindle. Enough paper must be wound on to permit the spindle and paper to make a tight fit when pushed into the hole in the middle of the drum. If the reader have any doubt as to what is meant, he should consult Fig. 90.

The spindle being thus fixed in the drum, slip over each end one of the card discs with a brass disc attached, the brass being in each case outside.

Then slip on two washers of thin wood, such as fretwood, the holes in which just fit the spindle tightly; and, last of all, run one of the nuts on to each end, tightening them up so as to press the various discs of the drum together tightly.

The mechanical part of the armature is then finished, except for one thing. The ends of the spindle are threaded still, and in this condition would not run satisfactorily. To get rid of the spare threads, rig up two wooden blocks with a small V-shaped groove cut in each, so that the two ends of the spindle will lie in the grooves. Then, holding it thus, carefully file away the threads until the bottom of the same just disappears. The thread is probably of equal depth throughout, and so by using the bottom of the threads as a guide it is possible, even with a file, to make the ends of the spindle quite round and true.

Bearings.—It is not necessary to describe these in detail, as they can be made in the same way as those for the steam turbine, described in Chapter XV. However made, they will be supported, of course, on two wood blocks fixed upon the base, as shown in the plan (Fig. 89). The precise position of the armature upon its spindle can be judged from Fig. 90. It is not of great importance provided there be enough of the spindle projecting at one side to go well into the bearing, and enough on the other to go through and leave a piece projecting

beyond the bearing for a small pulley, with which to drive something by means of a belt. This pulley may well be one of those small brass ones made for venetian blinds, and sold at all good iron-mongers for a penny. The end of the spindle should be filed slightly taper, and the hole in the pulley be enlarged with a reamer until it just fits. Then, if firmly pressed on, it will hold tightly.

Winding the Field Magnets.—Wind round the cores of the field-magnet coils 4 oz. of No. 30 silk-covered wire, half on each. Wind one coil, then carry the wire down one block, across the base, and up the other block to the other coil, so avoiding a joint between the two. Each coil must be so wound that on current passing along the wire it will pass round both coils *in the same direction*—that is to say, if one looks upon the machine from above, the current must flow "clockwise" in both or "anti-clockwise" in both, not clockwise in one and anti-clockwise in the other. This is essential.

It is worth while to wind these coils carefully, getting the turns even and neat, without any waste spaces between. It is good, too, to give a coat of shellac varnish after each layer of wire has been wound, for that not only adds to the insulating power of the covering, but tends to keep the wires firm and the coil solid.

Winding the Armature.—Thicker wire should be

used for the armature, say, No. 16, and it also must be insulated with silk. This wire is put on in short lengths. Each length lies in a slot passing across the width of the drum, being connected at each end to the brass discs. The wire must be cut to suitable lengths, and a bundle of such lengths sufficient to fill a slot must be laid in each, the ends being then bent over and soldered to the brass disc at each side of the drum.

The best procedure is to fill all the slots with straight wires, and then carefully bind them all in with strong thread wound round the drum in the two grooves left for the purpose. This done, paint them all well over with shellac varnish, which will soak in, to a certain extent, between the wires and help to bind them all together.

After the varnish has set, the ends of the wires are turned over and spread out over the surface of the discs so that they can be easily soldered. Cut the wires a little long to commence with, as it is easy to cut a little off when the soldering time comes, whereas, if any be too short, trouble will be caused. The insulation should be scraped off at the ends, so that the wires make a good electrical connection with the brass discs, but enough insulation must be left on to ensure that the wires shall not make electrical contact with the drum itself.

To ascertain the number of feet of wire required

for the armature, measure the average length of a wire connecting the two brass discs through a slot, remembering that the wires in the outermost layer will be the longest. Then judge how many wires about $\frac{1}{16}$ in. thick will fill the slot, and from that you can ascertain the total length required.

The Interrupter.—Finally, there remains the interrupter, to change the continuous current from the battery into an intermittent current, without which this kind of motor will not work.

This is a familiar feature of every electric bell and shocking coil. It is best to buy this little part, as it is very difficult to make one that will last satisfactorily. The spring with iron plate at one end, the pillar to support the same, and the similar pillar with platinum-pointed screw can all be obtained for a small sum.

It can be mounted very conveniently upon a little shelf on the side of one of the blocks. The arrangement of the parts is too well known to need detailed explanation, but it may be well to state this much: the current from the battery is led to the contact-pillar, whence it passes through the spring to the spring-pillar, and from it to the coils. The iron plate on the end of the spring is then attracted to the end of the yoke, which it nearly touches, breaks the contact, and stops the current. The magnetism in the yoke then ceasing, the spring flies back once more and makes contact again.

Thus is the continuous current converted into an intermittent one.

This motor will work well with a battery of a couple of cells, and will drive models and other small machines.

AN ELECTRIC BEAM ENGINE.

The simple little machine about to be described develops very little power, but is interesting as an application of magnetic attraction. The principle of it is that an iron armature, A (Fig. 91), attached to a long pivoted lever, L, which is connected with a crank and flywheel, is attracted periodically by a fixed horseshoe electro-magnet, M, and keeps the flywheel in motion.

The general features of the motor are shown in Fig. 91. The lever is of thin wood, tapered off towards the crank end, and counterweighted at the other so as almost to balance. It is pivoted on a stout wire passed through the turned-up ends of a piece of thin strip brass fastened to a wooden upright.

The magnet is of the kind used in electric bells, and may be purchased second-hand for a very small sum.

The crank has a throw of about $\frac{3}{16}$ in., and the armature a vertical movement of less than $\frac{3}{8}$ in. The height of the pivot must be such that the armature, when the crank is in its lowest position, does not quite touch the cores of the magnets.

Magnetization must begin soon after the crank begins to descend, and cease just before the crank comes under the crank shaft. The electrical circuit is made and broken at the right moment by a revolving brass contact, C^1, which touches an

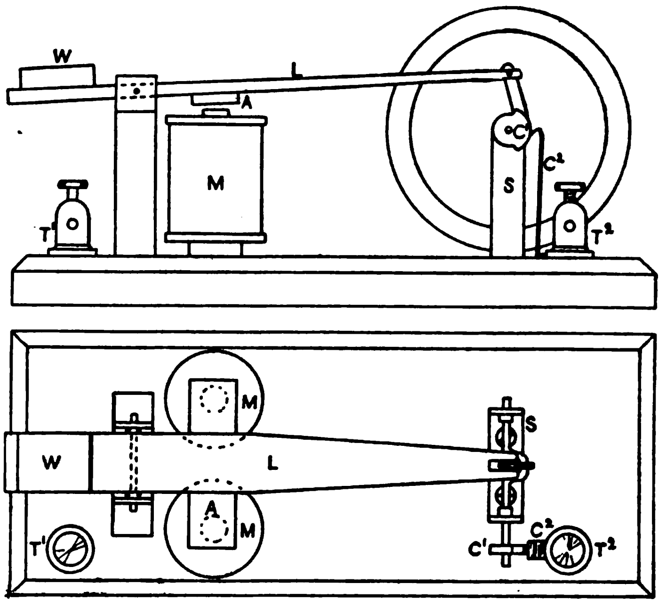

Fig. 91.—Electric beam engine.

upright piece of brass strip, C^2, during the descent of the crank. C^1 should fit the crank shaft tightly, so that it may stick in any position to which it is adjusted. The piece C^2 needs careful arrangement so as not to touch C^1 when the "bulge" is

not facing it. The bottom of it is clamped under a binding-post, T^2.

The crank shaft turns in standards, S, formed out of a single piece of brass strip. Small collars are soldered to the shaft inside or outside its supports to keep it steady lengthwise.

One end of the magnet-winding is connected with terminal T^1, and the other end of the winding with S. To work the motor, connect T^1 and T^2 with the two poles of a dry battery or accumulator giving 4 or 6 volts. The stronger the current the quicker will the motor run.

Friction should be kept as low as possible, since the pull of the magnet is small except when the armature almost touches it.

Chapter XVIII.

SOME MECHANICAL NOVELTIES.

An Electric Power Hammer—An Electric Gun—A Stern-wheel Steamer—A Gramophone Pump—A handy Blower—A Date Indicator—The Magic Cubes.

AN ELECTRIC POWER HAMMER.

THIS effective little model is an easily-constructed novelty, which, though of no practical use, will give much amusement to young people. The steam cylinder of a steam-hammer is here replaced by a hollow coil, A, wound with silk-covered wire. When an electric current is passed through this, it sucks up, as it were, the steel rod, F, to which a hammer, H, is attached. Just before the hammer reaches the top of its stroke it automatically breaks the circuit, and is left free to fall by its own weight. Before the end of the down stroke the circuit is completed again, and the hammer rises. The vibrations will continue as long as current is supplied to the coil. (Fig. 92.)

The *bobbin* of A is a brass tube soldered into two plates which form the ends. The upper end of F

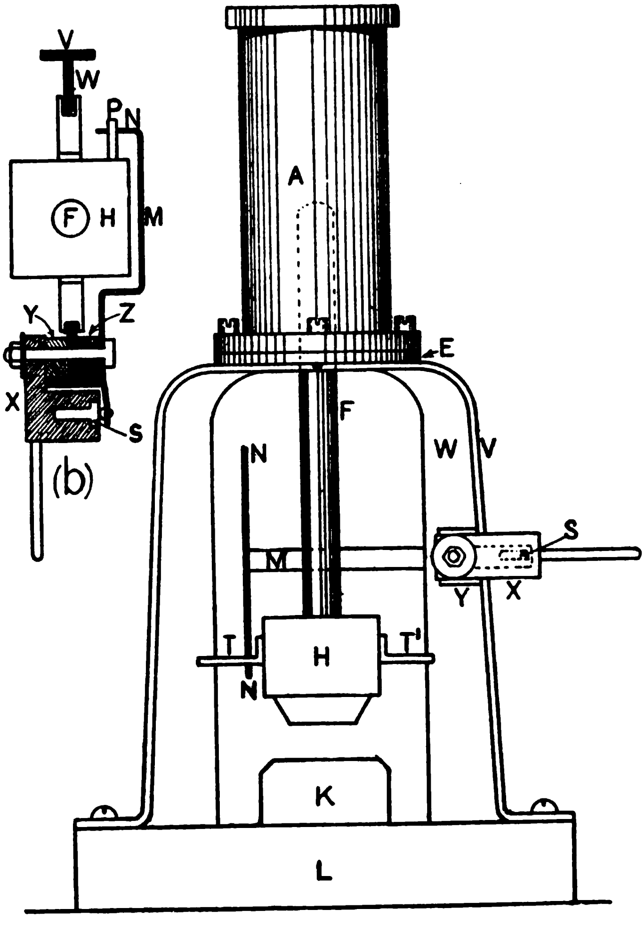

Fig. 92.—Electric hammer.

is nicely rounded off and polished, so that it may not tend to catch in the tube.

The *frame* consists of webs, W W, and a flange, V, centred on and attached to the webs. It may be carved as a whole out of hard wood, rubbed smooth and painted with aluminium paint; but a more satisfactory article will be made by cutting the webs out of $\frac{3}{32}$-in. sheet brass and soldering them to a strip running all the way round, and ending in feet by which the frame is secured to a block of iron, L. To this last is soldered the anvil, K, when the hammer is in position as a guide.

The inner edges of the webs must be quite parallel and at right angles to the bed.

A brass plate, E, $\frac{1}{8}$ in. thick and of the same diameter as the bottom flange of A, should be marked for drilling exactly at the centre and secured by four screws to the bobbin. Drill the hole and clean it out till it is the same size as the bore of the central brass tube. Then detach it and centre it on a mark made at the centre of the top flange and the frame exactly halfway between the edges of the frame flanges. Solder it in position and make a clean hole through the top of the flange.

The *hammer* is a block of iron, or of brass faced at the bottom with a steel plate, soldered or screwed on. The shaft hole should be started with a small pilot hole drilled on a machine to ensure squareness, and be cleaned out to size with a larger drill. Tap-

ping the block for a screw thread on the shaft will make the neatest and most satisfactory job, but pinning or soldering will suffice. To the sides of the hammer are affixed small brackets, T T^1, with slotted ends which run on the frame flanges (see sketch *b*) and prevent the hammer turning, besides keeping it centred in the coil.

In line with T is a pin, P, shown in (*b*), which strikes against arms, N N^1, on a *contact-breaker* or automatic switch, M. This switch is made out of brass, being either cut out in one piece or built up out of a strip for the horizontal part and a piece of wire for the arms. The distance apart of N N^1 should be such that P touches one or the other of them when the hammer has reached within half an inch of the end of a stroke. The cross-sectional sketch, (*b*), shows that a brass packing block, Z, is fixed in the back of the frame with its surface flush with the flange; and another, Y, in line with it on the other side of the web. (The frame is indicated in solid black.) A bolt passes through M, Z, the frame, Y, and a block, X, of insulating material. A spring washer under the nut will keep them all in close contact without preventing movement.

Near the rear end of M is soldered the head of a round-headed brass nail, which sweeps over a small brass contact-piece bedded flush in X. This is shown dotted in Fig. 92.

Connections.—One end of coil to one battery terminal; the other end to the frame (or, if this be of wood, to the bolt through M and X); contact S to the other battery terminal.

The hammer may be worked by moving X up and down by hand, or be allowed to run itself automatically. In the second case the amplitude of the hammer's movement may be controlled within limits by moving X, so that the pin P strikes N earlier or later in the upstrokes.

AN ELECTRIC GUN.

From time to time inventors have produced guns which discharge missiles by means of magnetic attraction, the general principle being that the projectile is drawn through the gun by a number of solenoids (coreless coils) which are brought into action successively by the projectile itself.

In Fig. 93 appear a side elevation and plan of a gun 16½ in. long. (The left-hand end is the breech.) It consists of a perfectly straight brass tube of ½-in. bore encircled by three coils, E^1 E^2 E^3, equally spaced. The bobbins of the coils have only a very thin ring of wood between them and the tube, and this may with advantage be dispensed with altogether, discs of wood being cemented in place to confine the wire, which is wound directly on the tube. As a powerful current is required, we will assume that the gun will be connected up with a

110-volt supply. Each coil should then consist of 2 ozs. of No. 16 cotton-covered wire. The ends of the winding should come out through the bobbin ends, on the same side of the centre.

Three openings, F^1 F^2 F^3, $\frac{3}{4}$ to $\frac{7}{8}$ in. long and $\frac{1}{4}$ in. deep, are made in each side of the tube by filing away part of the circumference with a flat file. These slots come just behind the coils to which they belong respectively. The inside of the forward end of each slot should be bevelled off slightly to prevent the projectile catching in it.

The tube, with coils on it, is fitted to a "carriage" —a block of wood $1\frac{1}{2}$ in. thick, hollowed out to admit the lower parts of the coils. A strap, H, at each end secures the barrel firmly to the base.

Just behind each slot, on each side, is placed a block of wood fibre, K, with a terminal, T, and a wire brush, W, curved at the end and arranged to enter the bore through the slot and touch the projectile as it moves along the barrel. These brushes, which must be quite springy, should be kept from touching the barrel.

The heavy dotted lines in the plan view indicate the system of connecting up the switches and coils. Terminals T^2 T^3 are connected with the supply. One end of each coil-winding is connected with T^2, and the other with the terminal T of the brush on the same side. The companion brush is connected with T^3.

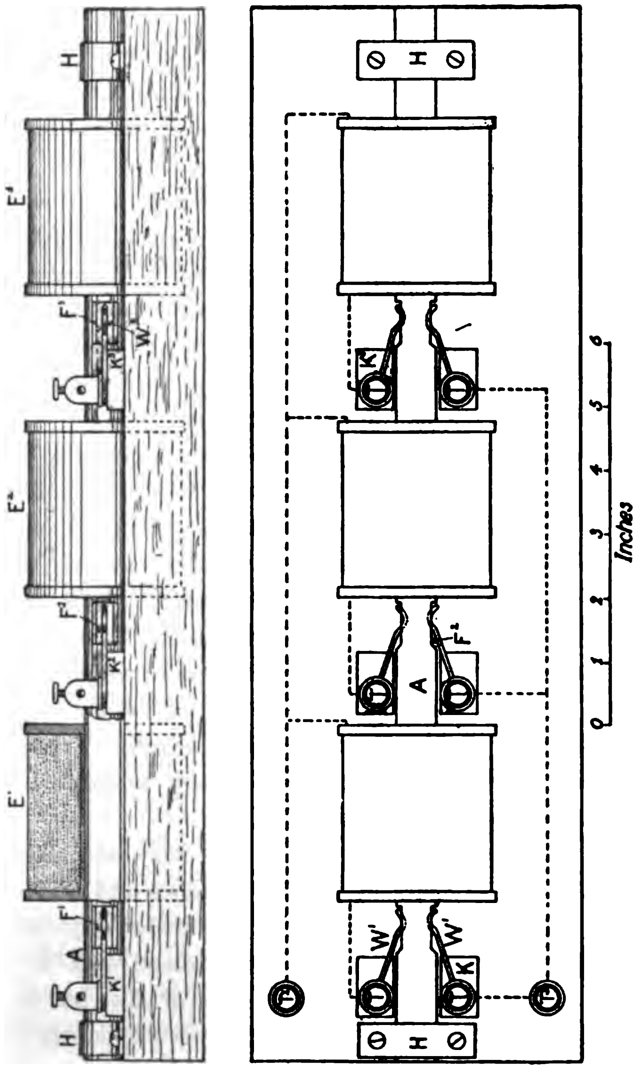

Fig. 93.—Electric gun.

The projectile is three inches of soft iron tubing, having a tail of wool thrums at the rear end and a hard steel point at the other. In fact, it resembles an air-gun dart on a large scale. The current having been switched on, the dart is pushed in at the breach until it presses on the first pair of brushes, W^1 W^1. The circuit is completed in coil E^1, which sucks the dart forward into itself, and in so doing breaks the circuit. The dart has sufficient momentum to continue on its way to the next pair of brushes, which energize coil E^2, and the speed increases, further velocity being added in like manner by E^3. If the barrel be long enough to accommodate four, five, or six coils, the muzzle velocity will be increased accordingly.

A three-coil gun made in accordance with the above description threw a dart 12 ft. with sufficient impetus to drive the point well into a board.

The amount of current used is of course inappreciable, as each coil is energized for only a minute fraction of a second.

A STERN-WHEEL STEAMER.

The craft shown in Fig. 94 is, for ease in construction, of a somewhat primitive character, having a parallel-sided hull with ends sloping up like a punt. But, of course, there is no objection to using a hull with properly shaped bows and stern.

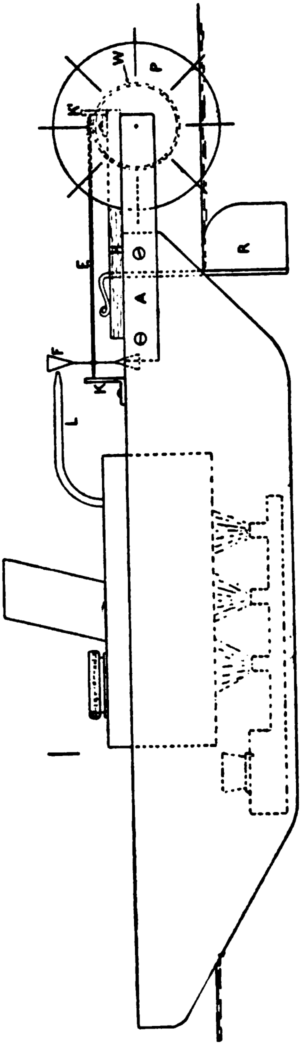

Fig. 94.—A stern-wheel steamer.

The vessel is propelled by a paddle wheel, P, at the stern, supported by a plate, A, on each side, screwed to the hull. The wheel is in two sections, mounted on an axle, an inch apart, to give room for a large toothed wheel, W (shown dotted), and a bar, H, which supports a bracket, K. This bracket overhangs towards the toothed wheel and holds the rear end of the rod, E, on which is a worm engaging with the wheel. A wheel section is merely two discs of tin with saw cuts in them to take the ends of eight strips which are soldered in to act as paddles.

The fan, F, is a tin disc slit radially. The parts between the slits

are bent through an angle of 45°, in that direction which makes the worm rotate the top of the toothed wheel, W, towards the ship. Shaft F is pointed at the ends, which lie in small conical holes in K K. The aim should be to make it turn very easily, so that the fan may attain a high speed—some thousands of revolutions per minute. For the same reason the axle of W should be fined down where it passes through the A plates.

A small pipe, L, with tapered end, directs the steam on to F. As the steam has a free escape there is no need for a safety valve. The boiler can be made of a piece of brass tubing with ⅛-in. discs soldered into the end, and a filler and dummy funnel attached to the top. The submergence of the paddle blades can be regulated by trimming the boat fore-and-aft with ballast. Rudder R has a springy tiller which presses downwards on A and holds R in any required position.

A GRAMOPHONE PUMP.

This little model is designed to be worked by a crank attached to the pin at the centre of the circular table of a gramophone. (Fig. 95.)

Required.—A tin pan 1¼ to 1½ in. deep and 7 to 8 in. in diameter; 3½ in. of brass tube ¾ in. diameter inside; 1 in. of brass tube, ⅜ in. inside; 1 in. of brass tube fitting the ¾-in. tube closely, but not tightly, for the pump bucket.

The Pump Barrel.—Bevel off what will be the bottom end of this to a sharp edge on the inside,

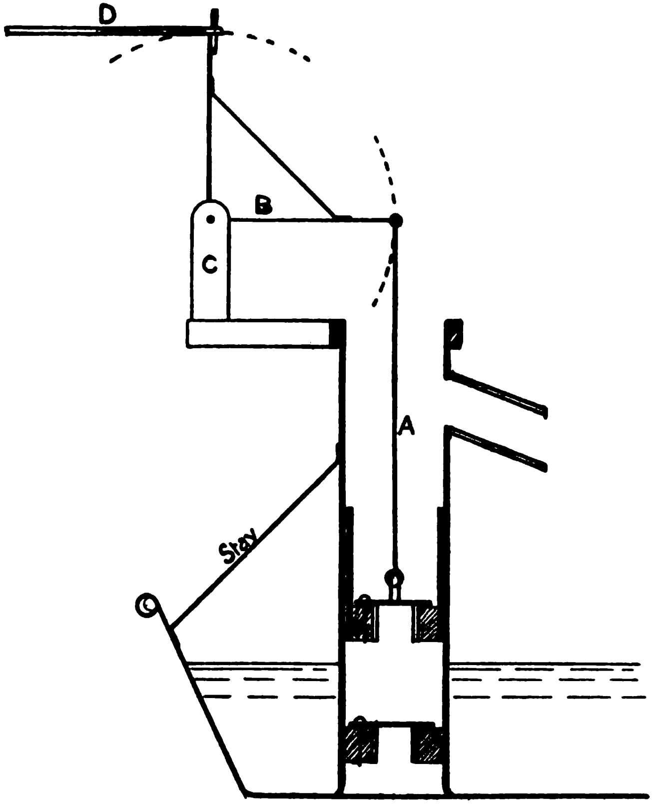

Fig. 95.—A gramophone-driven pump.

and file half a dozen deep nicks in the edge for water inlets. Find a cork that fits the tube well, cut off ¼ in. of it and burn a hole in the centre to

take a piece of ¼-in. pipe, which should just project above the top side. A valve is made by fastening a small piece of thin rubber (a small cycle tyre patch will do) by pins to the cork, which is then pushed up the tube till it is ¼ in. from the bottom.

The Bucket.—This is closed at the bottom by a cork plug with central tube and valve similar to that in the barrel. It is provided with a rectangular "stirrup" of thin wire spanning the valve, and has attached to it a strip of tin, A, to act as connecting rod. The upper end of A is pinned to one end of a bell-crank, B, also made of tin, and supported by an arm, C, encircling the top of the pump. An inch from the top of the barrel make a hole ⅜ in. in diameter and over this solder the spout of ⅜-in. pipe.

At the top end of B is a spike, over which is passed a loop at one end of the wire, D, connecting it with the crank. This last may be the top of a large cotton-reel with a pin driven in ⅝ in. from the centre to give the pump a stroke of 1¼ in.

The pump should be soldered to the bottom of the pan not far from the side, with its spout pointing to the centre, and be stayed at the back to the side of the pan. Give the pan a coat or two of enamel paint to prevent rusting.

When adjusting the pump for a run, place it with its back to the gramophone, and after fitting

the pump rod move the pan about until the pump bucket is in its lowest position when the crank pin is nearest the pump.

A HANDY LITTLE BLOWER.

This little instrument will come in useful for blowing up a fire, drying things, and removing dust; in fact, for all purposes for which a continuous draught of air is required.

The blower is shown in side elevation and plan in Fig. 96. The casing has sides cut very carefully out of a hard wood—oak or walnut by preference—spaced 2 in. apart and covered by a strip of sheet metal 2¼ in. wide. If thin brass be used, and be secured with brass screws and kept polished, the appearance of the article will be improved.

The drum of the blower is 4 in. in diameter inside. Holes 1¾ in. across are cut in the sides to admit air. Before cutting these make the two plates, A, in which the fan shaft revolves, bore holes in them for the shaft, centre the holes on the centre from which the circular part of the sides was marked, and screw them on. Remove them and cut the holes. This course will ensure the fan being properly centred.

The fan consists of four plates of thin brass, shaped and dimensioned as shown in Fig. 97. These are attached by the tail to a small block of wood slipped over the fan shaft and secured to

it. The closer these fit the inside of the casing (without, of course, touching it) the better.

The *handle*, H, is shaped out of a piece of wood $2\frac{3}{4}$ in. wide, $1\frac{1}{4}$ in. thick, and $5\frac{1}{4}$ in. long, the grip

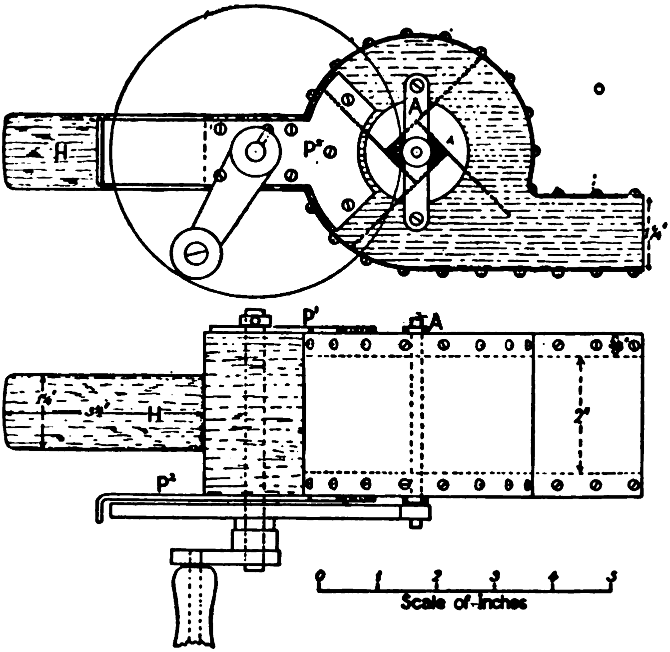

Fig. 96.—A blower.

being $3\frac{1}{4}$ in. long. If you possess a lathe the fashioning of this will be a very simple matter. The front face is hollowed to fit the casing, or is V-grooved; and handle and blower are held together by two plates, P^1 P^2, in which are bored holes for

the handle shaft. P^2 is made long and turned over at the end to form a hand guard. If H be placed somewhat out of centre away from the large wheel, this guard may not be needed.

The drive is transmitted from the handle to the fan either through toothed wheels—the most satisfactory course—or by friction, or by a belt. The fan should revolve ten to twelve times as fast as the handle. If plain friction be used, the large wheel should be rubber-covered and the small sheave be of wood, trued up after fixing in the lathe, if possible. With a belt drive, which will make the fan revolve in the same direction as the handle, either the apparatus as shown must be turned over and worked with the left hand, or the blower must be reversed relatively to the handle and be fixed with nozzle above the centre. Grooved pulleys and a belt of rubber cord are advised.

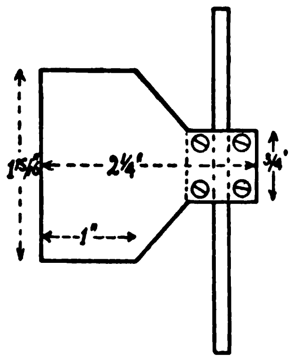

Fig. 97.—Plate for blower fan.

If the blower be intended chiefly for reviving fires, it will be advisable to lengthen the nozzle an inch or two and make it entirely of metal.

If electricity be laid on to the house a motor drive may be used, the motor being fastened on

the flat part of the handle and driving the fan by belt. If the motor be not suited to use the voltage of the supply, interpose a lamp in the circuit as resistance.

A DATE INDICATOR.

This article can be made at very trifling cost, yet is of practical use and constitutes an acceptable present. It consists of a small glass-fronted wooden case, containing three rollers, one for the months and two for the date strip, on which are the numbers 1 to 31. The clear dimensions of the case inside are : 5½ in. high, 3¼ in. wide, and 1¼ in. from front to back.

First cut a strip of wood 1¾ in. wide, ⅜ in. thick, and a foot long. An eighth of an inch from the edges of one face make grooves, ⅛ in. wide and ⅛ in. deep, from end to end, and then carefully cut off two pieces 5½ in. long, with ends perfectly square. These pieces form the sides, the grooves being for the front glass and the back. A base and top are made of rather thicker material. The edges of the top should be bevelled off to improve the appearance.

The rollers can be made very quickly on a lathe to the shape and dimensions shown in Fig. 98. If no lathe be available, cut two 5-in. lengths off a wooden rod ¾ in. diameter and one 5-in. piece off a 1⅛-in. rod. Cut a strip of stout paper 3¼ in. wide; and lap this round a roller with its edges

$\frac{7}{8}$ in. from each end. Use the edges as guides for pencil marks round the roller. A fine-toothed

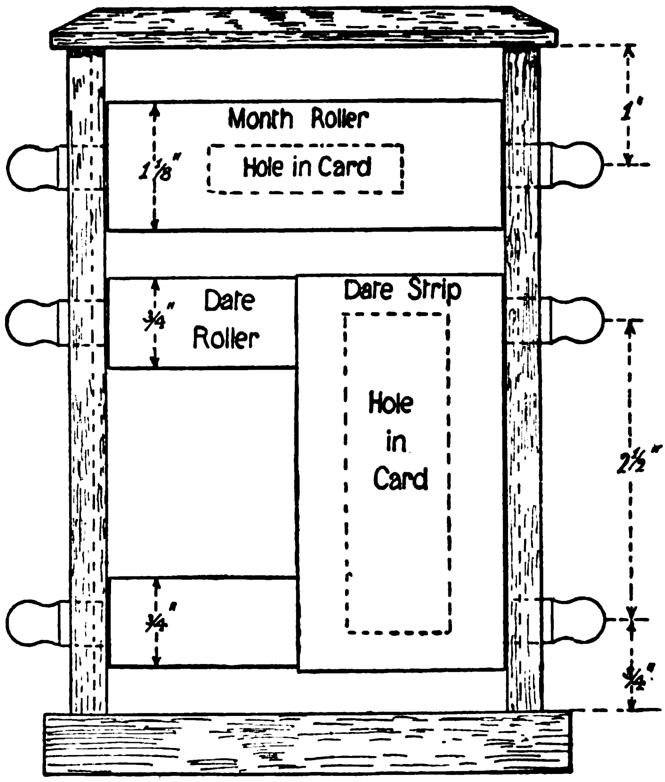

Fig. 98.—Date indicator.

tenon saw is then "blinded" with a couple of strips of wood clamped one each side of the blade by screws at the ends, to cut to within $\frac{3}{16}$ in. of the

axis. Cut just inside the marks all round as deeply as the saw can go. The ends are worked away carefully with a knife to $\frac{3}{8}$ in. diameter—the saw-cuts providing the gauge—shaped with a sharp knife, and smoothed up with fine sand-paper. The two other rollers are treated in the same way.

The names of the months are stuck in order round the large roller. These can probably be got from an old wall calendar. The letters should not be more than $\frac{3}{16}$ in. deep, and $\frac{1}{16}$ in. must be allowed between the names. The most satisfactory plan is to cut the names out very neatly, stick them on a piece of white paper, and paste the paper to the roller. For the date numbers a strip of calico $1\frac{3}{4}$ in. wide and 10 in. long is required. Cut out a 2-in. strip of *thin* white paper, 18 in. long, lay it on a clean board, and paste the upper face. Press the calico strip down on to it, leaving an inch clear at each end, clean off all superfluous paste, cover with clean white blotting-paper, and keep the strips under pressure till dry. Then trim off the paper to the width of the calico; and, beginning 4 in. from one end, rule in ink parallel lines, $\frac{3}{8}$ in. apart, across the paper. The numbers are then added between the lines in $\frac{1}{4}$ in. figures, centred on a vertical line $\frac{7}{8}$ in. from the right-hand edge. A neat penman can print them direct on the paper. An alternative is to borrow

figures from an old calendar and stick them on the strip.

The centres of the holes for the date rollers' ends are ¾ in. in from the front edge of the sides and 2½ in. apart vertically; the lower hole centre being ¾ in. from the bottom. The month roller centre is set back ⅞ in., and is 1 in. from the top.

The front glass, which can be cut from an old half-plate negative, must be wide enough to prevent the rollers being "pinched" by the sides. The back is of ¼-in. wood bevelled off at the edges to ⅛ in. Behind the glass is a card with openings for the month and a week of dates, as shown in Fig. 98. The names of the days of the week are stuck to the left of the "week" opening. These also may be borrowed from an old calendar. A black background with white lettering and marginal designs in colours and gold is very effective; but this is a matter for the choice and skill of the maker.

When all the parts of the case have been well sandpapered the sides should be attached to the base with the rollers in position. Insert the glass and turn the case on its face. Wind the date strip on to the top roller, passing the 1, 2, 3 end between the roller and the glass. The other end is brought round the other roller from the face side, and the rollers and strip are pressed sideways against the side of the case, after which the free end is attached by a couple of *small* tacks. Wind

the strip on to the bare roller, and secure the other end in like manner. This method should ensure the strip running true.

Insert the card and back, and secure the top by some fine brads. It then only remains to stain and varnish the outside of the case.

THE MAGIC CUBES.

A very attractive bit of "magic" may be performed with home-made apparatus. The trick is as follows: A plate is placed on a hat, and on the plate are piled successively a blue, a white, and a red cube. A cover with open ends—to ensure that "there is nothing in it"—is slipped over the pile, and, after a few passes of the entertainer's wand, is removed, disclosing only a blue and a red cube. The cover is found to be empty, but on removing the plate the missing white cube is discovered in the hat.

The first item of the apparatus is a hollow tin cube without a bottom. Mark out a sheet of metal as shown in Fig. 99, and bend along the dotted lines. The edges of the four sides are tacked together with a very little solder, which must be cleared away from the inside angles.

Next make three hollow wooden cubes which will fit the inside of the tin cube closely, allowing for the covering of paper. Great care should be taken to make them really cubical, so that they

will fit equally well all ways. Two of the wooden cubes are then covered with glazed white paper, and one with glazed blue paper; and the tin cube is encased (bottom included) with glazed red paper.

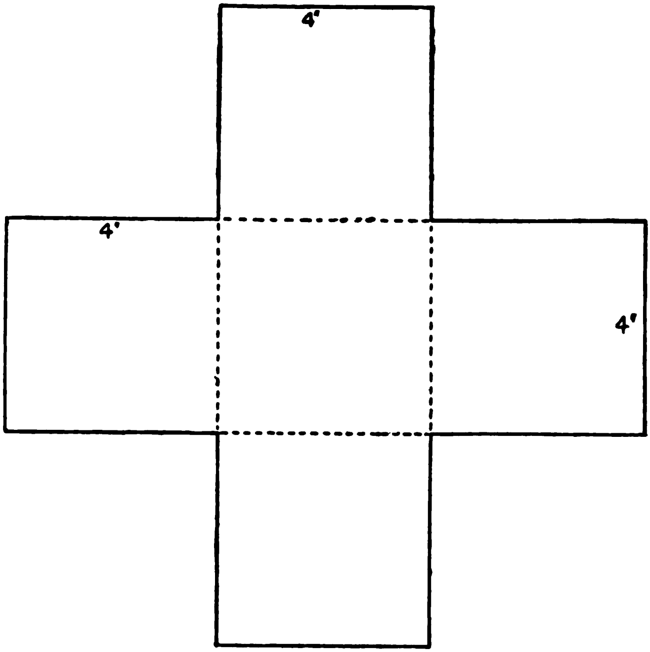

Fig. 99.—Marking out the hollow cube.

The cover (Fig. 100) now requires attention. It is made of thin wood, and must just fit over the tin cube and be as long as a pile of three cubes. The top end has a projecting beading, and two

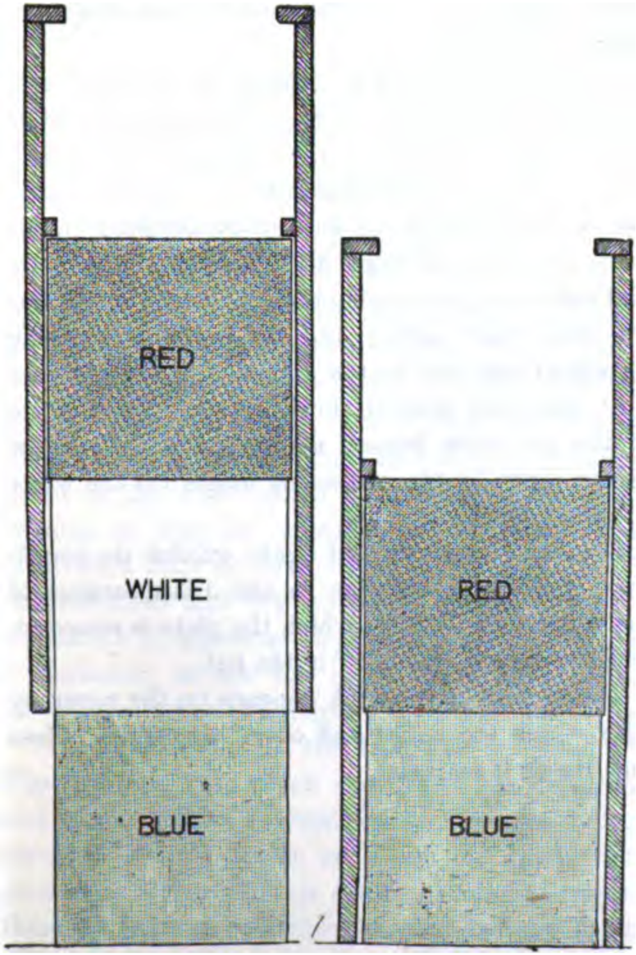

Fig. 100.—Box for magic cubes.

cubes' height up from the bottom two strips are fixed to the inside.

To perform the trick. Bring on the blue, red, and one of the white cubes, and stack them, blue, white, red, on the plate, the false paper bottom of the red being downwards. It is important that the red cube should be accurately adjusted on the white so that its sides all overhang. The plate and cubes are now stood on the hat, which contains the other white cube; and the cover, after being displayed endways to the audience, is slipped over the cubes and pressed slowly down. The bottom of the red cube bursts, allowing the shell to be driven down by the projecting ledges till the white is quite concealed.

Remove the cover and again exhibit its emptiness, and draw attention to the disappearance of the white cube. After which the plate is removed, and the cube is "found" in the hat.

The success of the trick depends on the accuracy with which the cubes and cover are made. Close but free fit is essential.

Chapter XIX.

A MODEL TANK.

SOME very ingenious working models of Tanks have been put on the market, and the demand for them shows that the attraction they have for young—and, we believe, old—people is considerable. In this chapter our attention is therefore given to the construction of a model driven electrically, so that its capacity for movement shall be limited only by the supply of current. Since accumulators and dry batteries are very heavy, the motor is connected by a flexible cord—which, if darkened, is not too much in evidence—with an *external* source of energy.

The general idea of the model is indicated by Figs. 101 and 102, which show it in side elevation and plan. Motion is imparted to the two endless bands or creeper tracks on which the model progresses by a pair of large drums or wheels, driving them by friction. At the nose and tail the bands pass round rollers, and are supported at intermediate points by other rollers. It is important

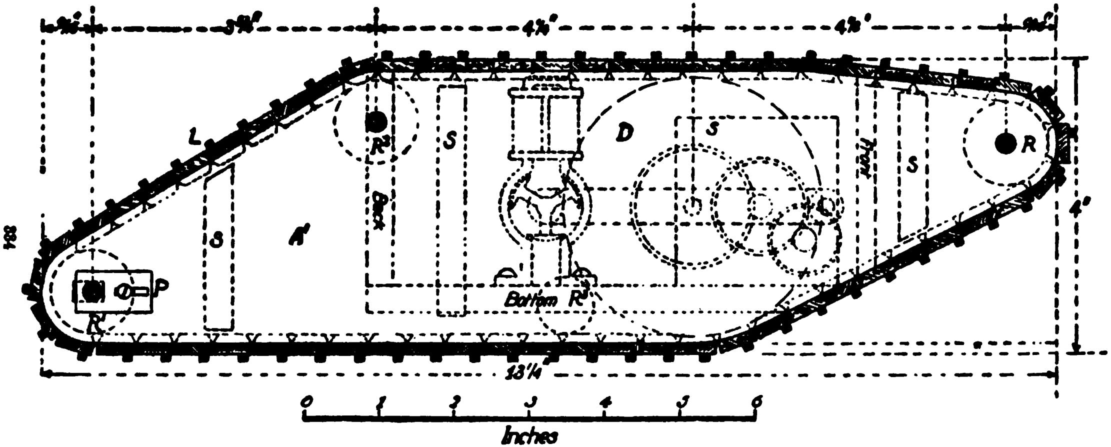

Fig. 101.—Side elevation of model tank.

that a good part of the model's weight should be concentrated over the points where the wheels press upon the bands, in order that sufficient friction may be set up between them; and at the same time to reduce friction between the bands and the fixed parts to a minimum.

The Motor.—This may be a very small one, but must have a tripolar armature so as to be self-starting. One of the vertical type with field magnet winding above the armature will be found convenient, as it occupies little room fore and aft.

The Gearing.—Excepting the "Whippets," real tanks are very slow-moving, about 5 miles an hour being their top speed. Models should therefore reproduce the very deliberate gait of the original monsters, and speeds such as those of model trains are therefore quite unsuitable. This is all to the good, however, as it justifies us in gearing-down the motor greatly and making its work so light that the model can easily be driven over obstacles.

The cheapest gearing obtainable is the works of an old drum clock of the kind that used to cost 3s. to 5s. Take away the hairspring and balance wheel, pallet and pallet wheel, and the train outside the frame which drives the hour hand. There will remain a train of four wheels. The main-spring must be removed and the spring wheel axle be replaced by a bar of steel of the same diameter but $4\frac{3}{8}$ in. long.

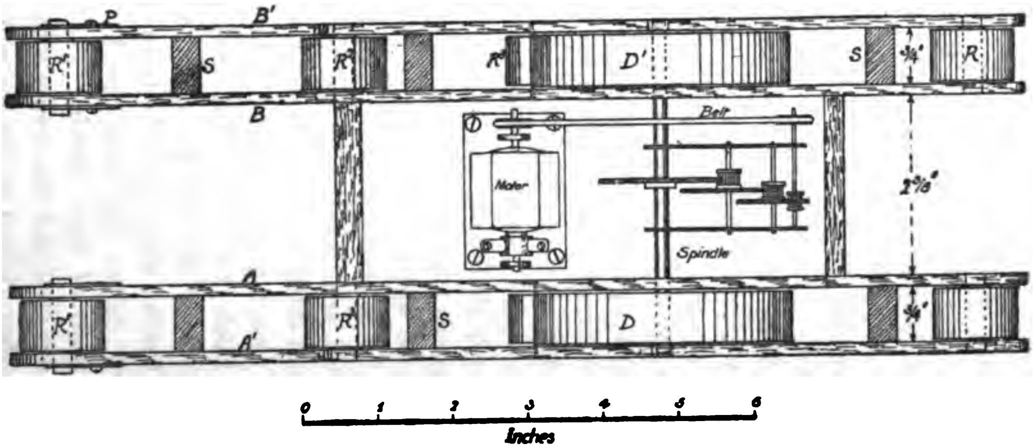

Fig. 102.—Plan of model tank.

The motor drives the spindle of the last wheel of the train—that is, of the one farthest from the mainspring wheel. As the toothed wheel on this is not required, it may as well be pressed off carefully; its place being taken by a pulley $\frac{1}{2}$ in. in diameter cut off a wooden bar of that size. This is connected with the motor's pulley by a ring of circular rubber cord. If the groove be made after the wood is mounted, a rest of some sort being used to support the tool, it will be quite true relatively to the spindle. The little extra trouble involved in substituting a longer spindle for the original, so that the pulley may be outside the frame, will be rewarded by greater ease of replacing the driving band if it should break, and by the ability to arrange the mainspring wheel farthest from or nearest to the motor, as may be desired. If the motor be close to the mainspring wheel, its weight will be employed more effectively in enabling the driving drums to grip the tracks.

Just one word of caution. As there are four wheels in the train, those at the ends of the train will revolve in opposite directions. You must therefore ascertain in which direction the motor runs and place it with its pulley on the left or the right as the case may demand. We may point out here that a long driving spindle makes it possible to centre the train frame and motor on the centre line of the body. If the pulley be inside the frame,

both cannot be centred. The motor, being the heavier, should then be given the preference.

The Body.—This is made of wood. Four pieces A A^1, B B^1, for the sides, and to carry the tracks, of the shape shown in Fig. 101, should be marked off from the same template—of thin card—and fretsawed out of $\frac{1}{8}$ to $\frac{3}{16}$-in. board just outside the lines. Clamp the four pieces together and work their edges down smooth in one operation. If a small square be used occasionally across the combined edges, this will ensure their being of exactly the same size and shape. Holes are bored in what will be A and B to fit the drum axle.

The pieces enclosing the ends of the central chamber are $2\frac{3}{8}$ in. wide. They must match accurately and have perfectly parallel vertical edges. The bottom and ends are of $\frac{3}{8}$-in. stuff. The bottom and front are attached by screws through the sides, A and B. The back is screwed to vertical square bars on the inside of A and B. The top is removable and hooked to the ends.

The exact position of the bottom will depend on the dimensions of the motor. If possible, the last should be screwed direct to the bottom. Decide what is to be done by putting the drum spindle through the holes in A and B and arranging the clockwork frame and motor. One or the other of these may need packing up. The train frame is secured by small straps passing over the two

bottom corner bars which hold the sides of the frame together. It is very important that the spindle be free from bending stress at the centre, and to ensure this the frame must be adjusted accurately.

The Drums.—These, D D^1, are $\frac{5}{8}$ in. wide and $3\frac{7}{16}$ in. in diameter. They should be turned up out of hard wood, such as beech, and be centred as accurately as possible on the main spindle, so as not to wobble at all sideways. The spindle is long enough to project $\frac{1}{8}$ in. through them when they are in position. To prevent them slipping on the spindle, square off the tips of the last and fit small plates with holes to match. These plates are secured to the outer faces of the drums by tacks, and the plates are soldered to the spindle. This, however, is not done till the model is finally assembled.

The diagrams show that the circumference of D D^1 lies slightly inside the edges of A A^1 and B B^1, since the track plates extend inwards a small distance between the inside edges of these pairs of side plates. (See Fig. 101.)

The drums should be covered by rubber bands of the same width, large enough to go on without excessive stretching. The bands will get a better grip of the track tapes than would the bare wood.

The *rollers*, R R, R^1 R^1, and R^2 R^2, are cut out of the wooden reels on which sewing silk is sold.

They are about $1\frac{1}{8}$ in. in diameter at the middle. Very carefully pare away the flanges of six such reels to form six cylinders, and cut off a piece $\frac{5}{8}$ in. long from each, measuring from the flat end. These must be provided with wooden spindles on which they turn easily but without looseness, after the central holes have been polished as perfectly as is possible with a circular file and a twist of emery cloth. The spindles and the inside of the rollers should be well rubbed with black lead, which is an excellent lubricant for wood. The holes for the spindles are so located that, as in the case of D D^1, the circumferences of the reels are set in a little from the edges of the side plates. As the bands of the tracks may stretch slightly with use, it is advisable to make longitudinal slots for the spindles of R^1 R^1, so that the last may be moved backward a little when the need arises. The spindles are held in position by small slotted plates, P P, which are screwed to A^1 B^1.

The tank may run rather more easily if a fourth pair of rollers be placed at R^3 R^3, to hold the tracks away from the side pieces just aft of the drums.

Small rings of wire should be interposed between the ends of the rollers and the sides to prevent rubbing. A and B are separated $\frac{3}{4}$ in. from A^1 and B^1 respectively by the spacers, S S^1—glued to A and B and screwed to A^1 and B^1—which also prevent the pieces warping.

The Tracks.—These are the most troublesome parts to construct, as they require care and the expenditure of a good deal of time. Each "plate" of a track is $\frac{1}{2}$ in. broad fore and aft, $1\frac{1}{16}$ in. wide, and $\frac{1}{4}$ in. thick. The plates are attached to tape $\frac{5}{8}$ in. wide, which should be well stretched before use.

For the plates select a sheet of $\frac{1}{4}$-in. oak or mahogany, and off it cut strips 1 in. wide *across* the grain. In the edges of each strip make rebates $\frac{1}{8}$ by $\frac{1}{8}$ in. as shown in Fig. 103, *a*. Sandpaper the rebates well and bevel the sides slightly. (Fig. 103, *b*.) Try the strip between the A and A[1] and B and B[1] to ascertain whether it slides easily. If there be any tightness, scrape away the wood carefully wherever there are signs of friction.

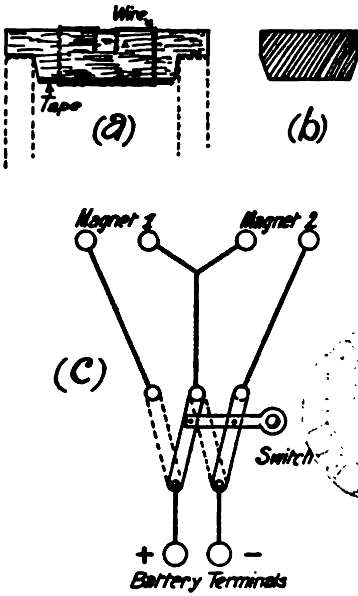

Fig. 103.—(*a* and *b*) Details of track; (*c*) three-way switch.

When strips of a combined length equal to twice the circumference of the side plates have been

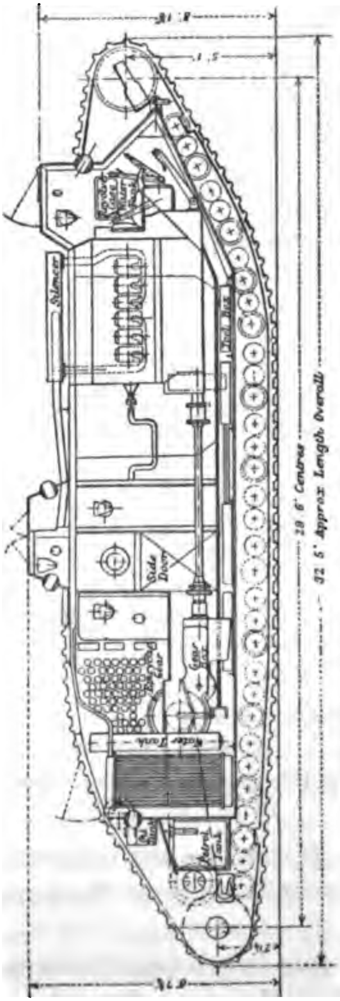

Fig. 104.—A Mark V* tank: side view.

prepared, cut them along the grain into strips ½ in. wide. All cuts must be quite square to the edges. Smooth the raw edges with emery cloth.

In the centre line of each plate bore two very small holes ¾ in. apart and equidistant from the ends. A small template may well be used to ensure all the plates being similarly bored. These holes are for the arms of a wire clip, of the kind used for binding magazines, which are passed through the tape and turned down. The clips are made out of thin wire, of which 1¾ in. are required for each. They had

better be shaped on a form, to get standardization of size.

After the clip has been passed through a plate of the tape, turn the latter over, bend the ends of the clip over for $\frac{1}{8}$ in. and drive them into the tape and wood along the centre line, backing-up the plate with an anvil or some other heavy and hard object.

If the plates be spaced out $\frac{1}{8}$ or $\frac{1}{4}$ in. the work will not take so long, but the appearance of the tracks will not be quite so good.

When the belts are nearly completed, lap them over the side-pieces in position—the adjusting rollers, R^1 R^1, being in their most retracted position—and measure off carefully, allowing $\frac{1}{8}$ in. overlap. Cut the tapes and sew the ends together with three cross rows of stitches; then complete the fixing of the plates.

The tracks will look more businesslike and get a better grip if each has a match stick glued across it just in front of the clip.

Before the tracks are put in place rub the rebates of the plates and the surfaces on which they slide with a mixture of soft soap and black lead, working it well in.

To get the tracks in position remove A^1 B^1 and stick pins into the free ends of the roller spindles. Then pass the bands round the rollers and drum and replace A^1 B^1. The pins will facilitate getting the spindles into their holes again.

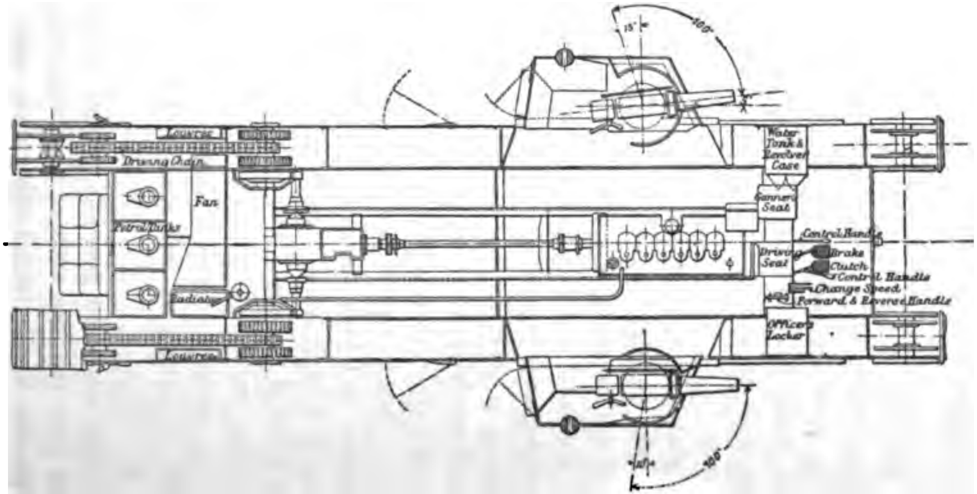

Fig. 105.—A Mark V * tank in plan, showing internal arrangements.

Now rub the tracks backwards and forwards until their contact surfaces run quite sweetly over the sides.

Finishing.—As regards the finishing off of the model, this must be left to individual taste. Side sponsons and barbettes should be added, and a model gun projecting from each of the first will give the realistic touch. For the sake of those who wish to get details very correct, drawings of actual Mark V* tanks are by courtesy of *Engineering* reproduced on a smaller scale from diagrams published in that journal. (Figs. 104 to 106.)

The woodwork should be painted khaki—care being taken not to let it get between the plates of the tracks—and then "camouflaged" by patches of other colours.

The cable from the accumulator enters the motor chamber through a hole in the back.

Suggestions.—If the pace of the tank be too slow, put a larger pulley on the motor spindle. The speed will increase in proportion to the increase in diameter of the pulley.

If the grip of the drums on the tracks be insufficient to send the tank up steep slopes, drive pins into the drums at intervals of ½ in. and cut them off just outside the rubber with pliers, holding these across the drums so that the edges of the stumps shall be transverse. As an alternative fit

two disc rollers outside, over the top of the drums, to press the track downwards against them. The discs are mounted on spindles which form the ends of springs. The match-stick grips will need "gapping" at the centre for the discs to pass through them. These extra rollers are not in the "real thing," but they will prove useful; and a model that is slightly incorrect, but works, is preferable to a correct one that doesn't.

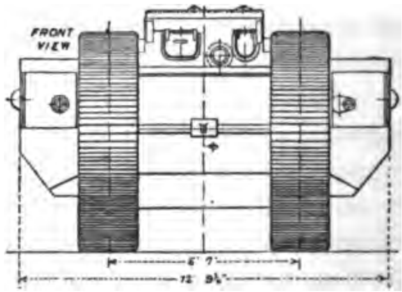

Fig. 106.—A Mark V* tank: front view.

Turning.—A real tank is made to turn by throwing one of the track motors out of gear and braking that track while the other continues working. A clever mechanic might wish to make his model do the same. The following is a suggested method of working it. The drums are mounted on pieces of tubing which fit the main spindle closely and have soldered to their inboard ends circular plates 1 in. in diameter with eight holes bored equidistantly

$\frac{1}{8}$ in. from the outside. A similar plate, which must be of iron, is attached to another piece of the same tubing, passed over the spindle. This plate has two round-ended spikes projecting from it, so placed as to fit into any opposite pair of holes in the other plate. The tube on which the spiked plate is mounted has a slot cut in it to take a small spike driven into the spindle, which prevents it rotating independently, though it can move lengthwise. A spring on the spindle normally presses the two plates together.

Straddling the second tube close to the moving plate are the poles of an electro magnet, which can be energized by the driver through the cable. To turn the tank he passes current into the magnet on the side to which he wishes the model to turn. The clutch is withdrawn and the motor swerves to that side. When it has turned far enough, current is cut off and the clutch comes together again.

This refinement will require three more wires to be incorporated in the driving cable, and a special two-way switch to be fitted on the switch board. The connections are shown in Fig. 103, *c*.

Chapter XX.

MODEL AEROPLANES.

IN the following article full and explicit directions (together with the necessary diagrams) are given for constructing two of the best types of models, namely—

(1) A model which can rise of its own accord off the ground, and alight on the same; and
(2) A model which can rise—also under its own power—from the surface of a pond, and alight, without damage, on water or land.

Certain parts of the models are the same in both cases, and with these we propose to deal first; but the reader should on no account commence to construct the models until he has studied the whole chapter.

The Fuselage.—We begin with the motor rod or fuselage and its fittings—the same for both models. The motor rod itself is 3 ft. long, and may be a solid rod of whitewood, $\frac{1}{2}$ in. square in section at

the centre, and tapering to ¼ in. square at the ends; or a ⅜-in. section (or, if something rather stronger be required, of ½-in. by ⅜-in. section) U-shaped silver spruce rod. One may also use a hollow spar of ⅜-in. square section. The three last named can be obtained ready-made from any good dealer in model aeroplane accessories; the first can easily be planed up by the reader himself. Comparing weight with strength, the hollow spar is the most efficient. Whichever be selected, it will be dealt with in the following manner.

A piece of streamline strut, H H^1 (see Fig. 107), of ⅜-in. section and 10¼ in. long, is fastened at its mid-point to one end of the motor rod, at right angles to it. A slot should be cut (X in Fig. 107) in the rod, and the cross-piece glued into it and fastened with a couple of brads. These brads are not the ordinary kind, but must be obtained from a dealer in model accessories; assorted packets cost about 5d. per oz. The two compression struts, L K, L^1 K^1 (Fig. 107), are made of magnalium tubing 3 millimetres diameter—the smallest obtainable. The ends for about ¾ in. are bent carefully with the aid of a pair of round-nosed pliers to such angles that they will lie flat on the motor rod and cross-piece, and are then hammered flat. A fine hole is drilled in each flattened part to take a brad of the kind already referred to. The ends may be further secured to the woodwork by binding neatly

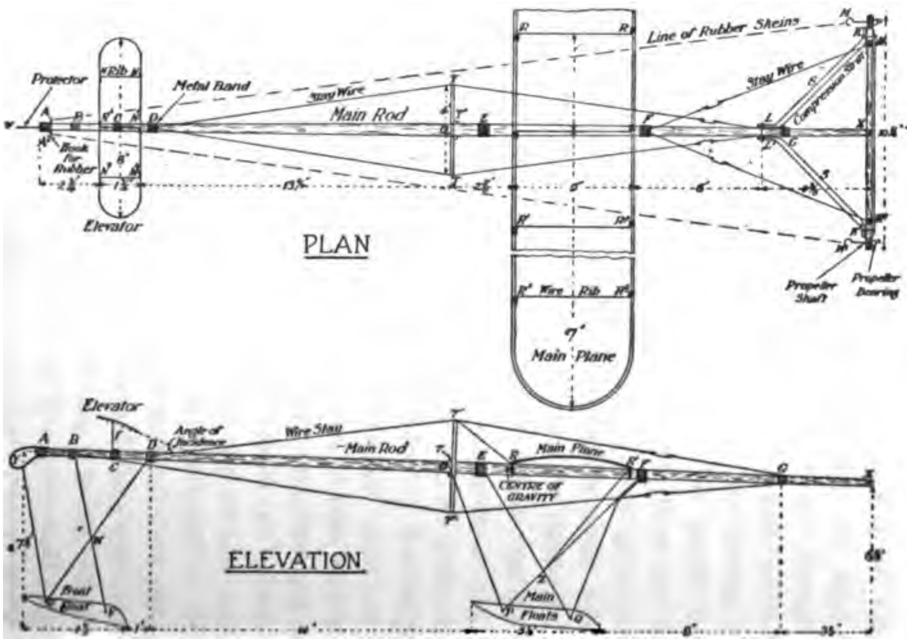

Fig. 107.—Plan and side elevation of hydro-aeroplane (one-eighth full size).

with thread. Note that magnalium is liable to crack, and must, therefore, be dealt with gently.

A, B, C, D, E, F, G, H, H^1 (Fig. 107) are narrow strips of the thinnest "tin" (sheet iron) procurable, bent tightly round the motor rod at the positions shown in the drawings, and lightly but securely soldered. The metal can often be obtained very thin from old penny toys: burn the paint off over a gas stove, clean well with emery paper, and cut with shears or an old pair of scissors to required sizes. If the motor rod be of U-shaped section wood, at these and other places where anything is fastened to it, or bound round it, tiny little wooden blocks must be inserted in the channel and glued, to prevent the sides of the U collapsing inwards.

Very small vertical holes must be drilled through D, F, G, H, and H^1, and horizontal ones in B and G, through which are passed the "staying" wires. These should be the finest piano-wire procurable (30 to 35 gauge).

The next thing to attend to is the double "king-post" or central mast, T T and T^1 T^1 (Fig. 107). This can be constructed of wood and given a bow form, as shown in Fig. 108, *a*, or it can be made from two steel hat-pins cut down to 4 in. in length. The latter offers the less resistance.

If the wooden bow form be preferred, a good tough wood should be used, and the four ends held

together by four small pieces of bent tin, nicked so that the stay-wires can lodge in them.

If the hat-pin method be employed, another strip of tin must be placed round the motor rod at O, and two holes be drilled at right angles through which the pins can pass. The fit should be a tight one, and each pin must be soldered to the two sides of the metal which it penetrates. About $\frac{1}{8}$ in. from the extremity of each pin wind a coil or two of fine soft floral wire, and solder it to act as a stop to prevent the wire stay (which should be passed once *round* the pin) from slipping down the same.

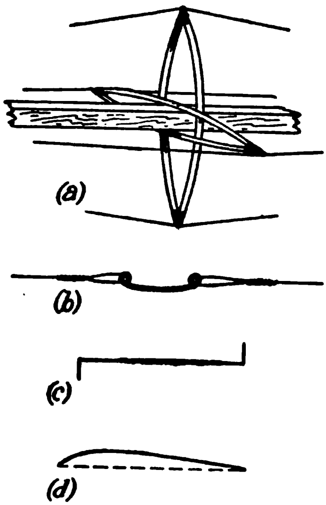

Fig. 108.—Details of aeroplane.

It is essential that each of the six stay-wires should be provided with a wire-strainer, as it is very important that the tension—each wire must be *taut*—be evenly distributed. Screw wire-strainers, 1 in. long and weighing $\frac{1}{16}$ oz., can be purchased at 3d. each or 2s. 6d. per dozen; or the reader can make use of the simple little device shown in Fig. 108, *b*, which is merely a piece of

steel piano-wire (18 or 20 gauge), which can be tightened or loosened by merely coiling or uncoiling the ends.

The "protector" Y (Fig. 107) is made of a piece of piano-wire (18 or 20 gauge) some 4 in. long, curled or bent as shown, and soldered to the top and bottom of the tin strip A.

A A^1 (Fig. 107) is a similar piece of wire bent as shown, and soldered to the sides of the same tin strip. It forms the hooks to hold the double skeins of rubber which supply the motive power. It is as well to *bind* Y and A A^1 with fine floral wire after they have *both* been lightly soldered, and then to solder them again, as they require to be firmly fixed. Don't use too much solder, since this increases weight unnecessarily.

Our motor rod is now fitted up, save for the bearings in which the propeller shafts rotate. These can take a great variety of forms. The lightest and simplest, and one which keeps the pull of the rubber motors in a straight line with the length of the motor rod, is a strip of tin bent tightly round the extremity of each end of the cross-piece, and drilled with a hole through which a propeller spindle passes.

There are two drawbacks to this form. In the case of the hydro-aeroplane, if the wood should get wet (it should, of course, be varnished with the varnish used for the floats, to which reference

will be made later on) it will swell and the spindle will run stiff. This can be obviated by having the hole in the wood larger than that in the tin. The other drawback is, that it is not possible to change one pair of propellers for another without unbending the rubber hooks on the spindle. If, however, we cut away about ¼ in. from each end of the cross-piece, and bind on it about 1¼ in. of umbrella ribbing, allowing about ¼ to ⅜ in. to project (having first drilled a hole in the same for the spindle to run in), this difficulty is overcome. To drill umbrella ribbing, which is very hard, first file a nick, then use a steel centre punch, and finish with an Archimedean hand-drill. Do not on any account attempt to soften the steel. In ordinary circumstances the strip-tin method answers quite well. There is no necessity to use ball bearings in so small a model, as they confer no perceptible advantage.

The Elevator.—We will next deal with the small leading plane or elevator. The models under consideration belong to what is known as the "Canard" type, which is by far the easiest type to fly and the one which gives the most satisfactory results, especially in the case of the hydroaeroplane.

The dimensions of the elevator are clearly shown in Fig. 107. It is framed out of piano-wire (22 to 24 gauge), and covered with Bragg-Smith proofed

silk, which material is also used for the main planes. N N, $N^1 N^1$, and $N^2 N^2$ are three ribs of similar wire. Their ends are bent at right angles for about ¼ in. (see Fig. 108, *c*), and soldered to the main wire frame, which is formed of a single piece of wire soldered at N^1. The ribs have a small camber or curve; the natural curve which the wire has when unwound from the coil may be left

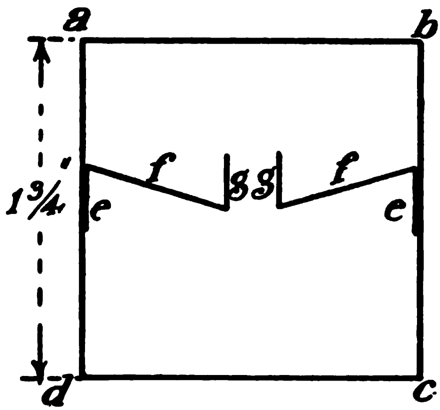

Fig. 109.—Support for elevator.

unaltered, or the wire can be straightened out and afterwards given the camber shown in Fig. 108, *d*, in which the left is the leading and the other the "rear," or, as it is usually termed, the "trailing" edge.

The fabric is now put on. To do this, first cut a piece the same shape as the plane, but about ¼ in. larger all round. This should be now pinned

in position and sewn on, the stitches being put in quite close to the wire. The fabric, which, as we have seen, overlaps, can, of course, be stuck together; but it is best sewn on, because this course permits any "baggy" part to be tightened up easily at any future time; and in the case of the hydro-aeroplane, a wetting will not unstick it or affect it in any way.

Some little skill and practice is necessary to get the fabric on evenly, neatly, and tightly. First of all, sew down one long side, then down the other long side, pulling the fabric tight at the same time. Next, sew one curved end, and finish up on the other, again pulling tightly the while. When completed, the plane will probably have a *small* curvature upwards towards each end—that is, it will contain a "dihedral angle," as it is termed. If it have, so much the better.

To fix the elevator in position in a way that will render its angle of incidence adjustable, a support is made in accordance with Fig. 109, which shows it as seen from above. It consists of a square frame, *abcd*, and two Z-shaped wires, *efg*, *efg*, which are seen somewhat foreshortened, the parts *f f* corresponding to *f* in Fig. 107. The parts *ee* are soldered to the frame, and the parts *gg* to the tin strip C (Fig. 107), one on either side of the rod. The frame is secured to the under side of the elevator by four little wire loops. The angle

of incidence is adjusted by bending the wires *ff* slightly backwards or forwards. The approximately correct angle of incidence is given in Fig. 107.

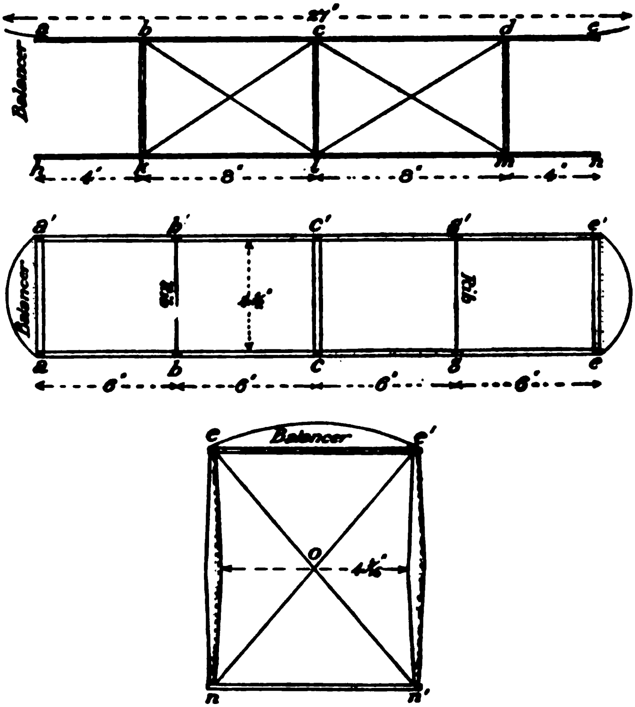

Fig. 110.—Front, plan, and side views of planes and supports for biplane.

The Main Planes.—In Fig. 107 a hydro-aeroplane with a single main plane is specified. The double planes shown in Fig. 110 are for the r.o.g. (rising-off-ground) model. The machines have been

so designed, however, that either machine may be a monoplane or a biplane, the only modifications required being in the chassis and the placing of the plane or planes on the rod.

So far as this latter point is concerned, the reader must (whether the machine be of the r.o.g. or hydro type, and whether it be a biplane or a monoplane) so place the main plane or planes on the motor rod that *the centre of gravity, or point about which the complete machine (including the rubber and propellers) balances, shall be just at the leading edge of the main plane or planes.*

This is a most important point, which must be strictly observed, as the relative sizes of main plane and elevator have been designed with this end in view. Moreover, this arrangement gives maximum efficiency and minimum head resistance.

As has already been stated, the r.o.g. drawings are for a biplane type of model. Let us consider the planes in detail. Fig. 110 shows them in elevation—that is, as seen from in front—and in plan, or as seen from above. The rectangular framework of the two planes can be constructed of whitewood (silver spruce is stronger, but heavier in the proportion of about 5 to 4) of $\frac{3}{16}$-in. by $\frac{1}{16}$-in. section, glued and pinned at the corners a^1, e^1, e, a, and with a similar piece across from c^1 to c; bb^1 and gg^1 are two wire ribs (20-gauge piano-wire), and there is a third across above the wooden rib from c to c^1.

These wires should be cambered, as shown in Fig. 108, *d*. They are held in position by narrow strips of tin bent round the wooden frame, *a*, *e*, e^1, a^1. Top and bottom planes are precisely similar.

We have next to connect the two frames. This is done by means of six struts, two of silver spruce and four of whitewood. These struts should be of streamline section from front to rear, and also tapered as shown in Fig. 110, since thus are obtained maximum strength where most wanted, minimum weight, and minimum head resistance—all three very important factors. These struts have a maximum width of about ¼ in., and a maximum breadth of about ⅛ in. The two silver spruce struts are employed at the centre, two of whitewood for each end.

The fitting of these struts to the spars of the main planes requires some little care; glue and a long, thin brad driven through the spar into the struts should be used. The reader should note that the two central struts are not put *quite* in the centre (although so marked in the drawings), but are "out" to the extent of half the width of the motor rod, because they are fastened to one side of this—which side is immaterial.

Having fixed the struts and planes together, allow at least twelve hours for the glue to dry and set thoroughly. The bracing wires, *e*, *o*, n^1, and e^1, *o*, *n* (Fig. 110), and the corresponding wires

on the other side, should next be inserted. Steel piano-wire, similar to that used for the bracing of the motor rod, is best. These wires should be only *just* taut. If you find any difficulty in dealing with the steel wire, soft iron wire can be substituted; but on no account should this latter kind of wire be used for the bracing of the motor rod.

The bracing wires *bl*, *ck*, *cm*, *dl*, and their fellows at the rear can next be inserted, *or* the fabric (similar to that used for the elevator) can be stitched on first. Or, if preferred, the planes can be covered *before* the struts are attached. On the whole, this last is perhaps the simplest procedure, since the various parts are then easier to get at. In this case the sewing should not be done close up to the sides, but ¼ in. in from the leading edge, and ½ in. in from the trailing or rear edge. The reader must bear this in mind when cutting out the fabric. The overlapping fabric can, of course, be stuck together with well-made, thin glue, but this course has the disadvantages already pointed out. The balancers or stabilizers (see Fig. 110) can now be put on. These are two semicircular pieces of thin aluminium foil. The straight edge of each is turned over about $\frac{3}{16}$ in., so as to double the thickness and stiffen it. A number of small holes are then made with a needle or fine punch just beyond this, and the aluminium "sewn" or threaded on to the ends aa^1 and ee^1, thin,

soft iron floral wire being used for the purpose. These stabilizers are not essential, as the machine will fly very well without them, but they do give the model additional lateral stability. They should be upturned, so as to make an angle of 35 to 40 degrees with the horizontal.

Instead of building the main planes as described above, the reader can, if he choose, build them of steel wire throughout—struts (save the two central ones) included.

A specially tempered steel wire (18 or 20 gauge) which opens out straight from the coil can be obtained from models accessory dealers, the price (including postage) being 8d. per coil; 20 gauge is quite thick enough. Such planes, if well made, not only offer less resistance, but are almost unbreakable. They will be, however, slightly heavier than those shown in the drawing. The number of ribs should be increased to six at least. The balancers will in this case form part of the main framework. The method of construction is similar to that of the elevator.

Copper or soft iron wire is used to attach the fuselage to the front and back spars of the main plane of the monoplane, and to the centres of the two middle struts of the biplane.

Wheels.—Next comes the question of the wheels. These should be of aluminium, and not less than 1 in. in diameter.

Plain-tyred wheels with long bosses should be selected. Three such will be required. Very light disc wheels should not be used, as a hard landing will probably double them up.

The *chassis* which connects these wheels with the main planes and motor rod is shown in Fig. 111, *b* and *c*. The compression struts, of 20-gauge steel

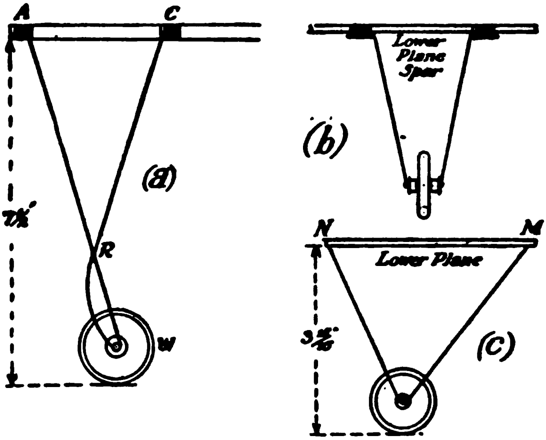

Fig. 111.—Chassis for biplane.

piano-wire, are practically unbreakable, and offer a minimum head resistance. The design is the result of a very long series of experiments, and all the best designers use it for small models. All that is necessary is to provide a light steel spindle on which the wheel axle can turn freely, but not loosely; to solder on two light metal shoulders or stops, twist

the steel wire round the axle outside the stops near the ends, and solder.

Fig. 111, *b*, *c*, shows how the wire struts of the chassis are fastened to the lower leading edge of the bottom plane. Each rear wheel has, of course, four struts, two running to the rear edge, N, and two to the leading edge, M, of the lower plane.

Fig. 111, *a*, shows how the wire struts or supports are arranged in the case of the front wheel, being soldered to the tin strips A and C. The joints can be still further strengthened by binding slightly with soft iron floral wire and soldering, or by means of a little overlapping strip of tin. The front chassis will be found very springy and strong. Be careful that the wheels are set in line with the motor rod or length of the machine, or else the model will not run straight. The wheels under the main planes should be set about 10 in. apart.

Our r.o.g. model is now finished, except for the motor and propellers.

The *motor* consists of two skeins of the *best* rubber,* $\frac{3}{16}$-in. strip, seven or eight strands to each skein. Alternative amounts are named because it is impossible to say exactly how far any particular builder will keep down the weight. If more than eight such strands be required, the machine must be considered as lacking in efficiency.

* Good rubber stretches to at least eight times its own length without fracture.

A model built by an expert will fly with six strands. When joining the rubber, do not try to make knots, but let the rubber ends overlap for about 1 in., get some one to pull the overlapped portions hard, and tie them in the centre with strong thread whilst so stretched.

The rubber must be well *lubricated.* Several good commercial lubricants are on the market. If the reader prefers to make his own, he will find a mixture containing the following ingredients very good: water, glycerine, soft soap, and soda. It is rather difficult to fix the best proportions for each, but 6 to 8 oz. water, 2 oz. glycerine, 1 oz. soft soap, and ½ oz. soda can be tried. These must be well mixed and boiled together for some time, then allowed to cool, and placed in a well-corked bottle for a day or two. If the mixture solidify or become like treacle, it is too thick; more water (but not too much) should be added, and the mixture reboiled. The lubricant should be fairly liquid to give the best results, and always be well shaken before being used. Do not try to clarify or filter the mixture.

All the wire hooks over which the rubber passes should be covered with pieces of rubber bicycle valve tubing; a pennyworth will be more than sufficient for all four hooks.

The Propellers.—These may be either "bent-wood" or "carved." The first are made by heating

or steaming a piece of thin wood cut to a certain shape, and bending it on to a " former " (if steamed), and fixing it thereto until it takes the shape of the same.

A " carved " propeller is cut and shaped directly out of a suitable block of wood without any bending. Both forms have advantages for rubber-driven models. Bentwood propellers show a tendency to become untwisted, especially those made by a non-expert. The carved or built-up laminated propeller can be truly shaped, and retains its form.

The writer strongly recommends, in the earlier stages of the art, the use of bought carved propellers of the " centrale " type. For the models with which this article deals, they should have a diameter of 10 in.; 9-in. ones may be used, but will not give equally good results. The efficiency of the propellers referred to (obtainable from any good dealer in model accessories) can be much increased, and the weight considerably reduced, by careful sand-papering, so as to give them a decided hollow or camber on what will be the rear or driving side. Some have a slight camber originally, but this can be improved.

The thickness of the resultant blades need be only about half that usually employed.

When buying the propellers (which must be, of course, of opposite pitch—one left-handed and the other right-handed), see that they balance prop-

erly on a piece of wire thrust through the central hole; an unbalanced propeller shakes the machine badly, and greatly curtails its flying capabilities.

The shaft of a propeller may consist of a piece of 18 or 20-gauge steel piano-wire. (A somewhat thicker shaft of silver steel is preferred by some makers.)

One end of the wire or steel should be filed or ground sharp and bent back. The longer part is passed through the hole in the boss of the propeller. If it fits loosely, it must be packed with copper foil or a thicker shaft be employed; in any case it must fit *tightly*. The sharpened end is now driven well into the propeller boss.

A small piece of brass tube is slipped along the shaft right up to the boss—this should fit tightly—and then soldered and filed off smooth. The other end of the shaft is turned up into a hook, and the shaft is passed through the bearing, and a piece of rubber (valve) tubing is slipped over the hook. It is most important that the shaft be not loose in the bearing, as looseness sets up vibration, which is detrimental to efficiency.

THE HYDRO-AEROPLANE.

We are now at liberty to turn our attention to our hydro-aeroplane model, in which the motor rod * and fittings, elevator, propellers, and rubber

* The motor rod is best made of $\frac{3}{8}$-in. U-shaped spruce.

motor are exactly described already. The same type of main planes can also be used, if desired, the two principal floats in this case being attached to the lower plane instead of directly to the motor rod. If two planes be used, the lateral flotational base can with some advantage be increased from the 7½ in. shown in Fig. 112, *a*, to 10 in. or even 1 ft.

The drawings are for a monoplane type of model, since this type has somewhat greater efficiency, and will give the reader the advantage of gaining some experience with the two types—the monoplane and the biplane.

In a hydro-aeroplane, owing to the floats being considerably heavier than wheels and offering greater head resistance, it is of special importance that the weight *and the total head resistance* should be kept down as much as possible.

Despite the difficult conditions imposed, the hydro model should fly with exactly the same amount of rubber as the r.o.g. machine. In this case—as in that of the biplane r.o.g. model—don't forget that the centre of gravity of the *complete* machine must be at the front leading edge of the main plane. If the weights of the various parts work out somewhat differently from those given, you must shift the main plane or planes along the fuselage until the necessary balance is obtained. The framework of the main plane in this model is constructed from magnalium tubing 3 millimetres diameter

with steel wire ribs, bent as shown in Fig. 108, *d*, bound neatly with thread, and given a coating of Bragg-Smith varnish. The ribs are bound to the *inside* of the tubing. First of all, however, the tubing has to be bent to shape. The semicircular ends are formed by bending round something circular (a jam jar, for instance), but of rather smaller diameter, as the tubing opens out to some extent when released; a wooden grooved pulley is about the most suitable thing. If the tubing be bent evenly and carefully, it will not be injured in the least. Only one joint is required; this should be at the centre of the leading edge. The easiest and best method of effecting it is to slip over the ends a piece of rather larger tubing about 1¼ in. long, fitting the frame fairly tightly. Fasten by punching it slightly in three or four places with a steel centre punch. *On no account drill a single hole anywhere in the tubing.* The tips or ends should then be bent upwards. Two wire stays should run from the front ends of the outermost ribs to the top of the centre kingpost, and two from the rear ends to the float fuselage. A couple of "drift" wires running from the same points to the front end of the motor rod can also be used, but the writer has not found them really necessary. Make quite certain that the plane has no "warp"; if it have, remove by careful bending.

The Floats and Chassis still remain to be con-

sidered. The latter is of steel wire, as in the r.o.g. machine. The manner in which the floats are constructed is shown in Fig. 112, *b*. The sides are of whitewood $\frac{1}{16}$ in. thick; and the top and bottoms of "Jap" silk, which can be purchased from any draper. Make two nicks with a flat file at the points.

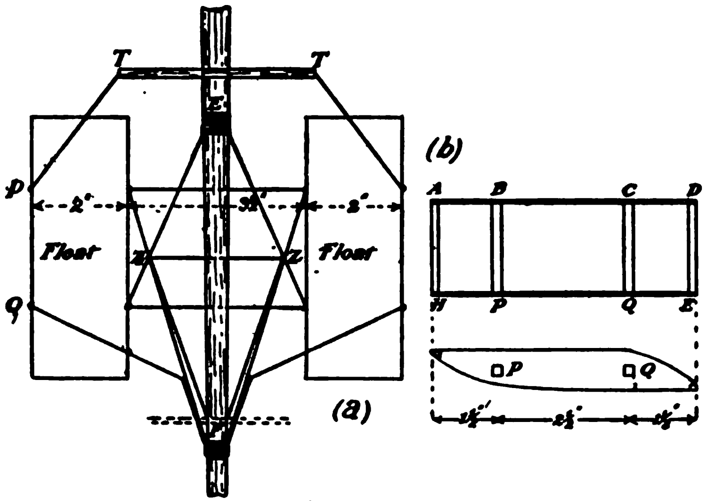

Fig. 112.—Floats for hydro-aeroplane. (*a*) Floats and connections to rod, in plan; (*b*) plan and side views of a float.

If you attempt to saw them, you are almost sure to split the wood, owing to its thinness. A H, B P, C Q, D E are strips of wood used to join the two side-pieces together—A H and D E $\frac{1}{8}$ in. by $\frac{1}{16}$ in.; B P and C Q $\frac{3}{16}$ in. square section. The first two are glued into the two nicks or slots; the

last two are merely glued to the two sides. A H and D E should be glued on first, and allowed to set. Lay the frame on a piece of something flat, and weight it on the top so that it may set true. B P and C Q answer the double purpose of staying the sides and acting as hold-fasts for the four ⅛-in. *thin* brass screws which are screwed into the two sides of the float at these points. The wire struts are twisted round these screws, and the screws (when the wire struts are in their correct positions) are screwed up tight. The screws used should have dome-shaped tops.

The next thing to be done is to put on the silk. The following instructions should be implicitly observed, since they detail the only means of getting the silk on really taut, and, unless it *is* taut, flotational capacity is lost, and the floats may prove too small. The actual floats used by the writer had a maximum depth of ¾ in., not of 1 in. as shown in the drawings. The extra ¼ in. is given to allow for a *little* extra weight and loss of buoyancy. First, cut out a piece of Jap silk 2⅜ in. wide, and of sufficient length to go right round the float framework from A H to D E along the top, back again to A H along the bottom, and overlap about ¼ in. Glue one end to A H, and allow to set. Next, make the silk *thoroughly* wet. Then glue on the top portion to the sides and top edge, working it taut with the thumb and first finger of both

hands, the frame being on a board or table. Allow to dry and set. Then wet the remaining portion, and glue it to the bottom and sides, and overlap on to the beginning. By using patience and care, it is possible to carry out the gluing in one operation, but the reader will probably at first get the silk on tautest by making use of the above method. If the silk do not dry as tight as a drum, remove it and clean the wood with sand-paper, and try another piece. One more point: Before gluing, it is advisable to give the woodwork a coat of the varnish that should be used to varnish the silk. Two coats should be given to the silk, two days elapsing between the first and second coat. This varnish is perfectly waterproof, even in the case of a long immersion, and does not discolour or turn white.

In making the floats, special attention should be paid to the corners; the silk requires trimming slightly, and must be well stuck down and well varnished. Before fixing on the floats, test them in a bath by immersing them completely for five or ten minutes. If they show *no sign* of leakage they may be considered satisfactory. If they have been properly and carefully made, they may be immersed for days without leaking. The manner in which they are attached to one another and to the fuselage or motor rod is clearly shown in Fig. 112. The wire struts seen in Figs. 107 and 111 are, of course, in duplicate. In Fig. 107, Y U is a thin

stay-wire, not a strut at all; also Z R^1 is a stay-wire to the rear edge of the main plane already referred to. Wire of 20, 22, or even 24 gauge will be found strong enough; always bear in mind that the weight must be kept down to a minimum. The angle at which the three floats are set is approximate only. The rear floats should be set at as fine an angle as possible.

Try the models first by gliding, and then in a light breeze or calm, always launching them against the breeze. Both models should fly high, so as to avoid trees. Neither model should *exceed* 6½ oz. in weight. Don't forget that the models fly small plane leading, and that the two propellers revolve in opposite directions, turning *towards each other at the top*, and driving the air backwards.

Chapter XXI.

A HOME-MADE KALEIDOSCOPE.

THIS original piece of apparatus gives most charming optical effects, which can be watched by a number of persons at one time, wherein it differs from kaleidoscopes of the ordinary type.

The kaleidoscope, invented by Sir David Brewster in or about the year of Waterloo, became so popular that over 300,000 instruments were sold within three months of its introduction to the public. In its simplest form it consists of two mirrors arranged at an angle to one another, which is some even submultiple of 360 degrees. The most convenient angles are 60 and 90 degrees, the latter of which always gives symmetrical figures.

By way of experiment, take two pieces of ordinary looking-glass and arrange them as shown in Fig. 113, *a*, on a piece of colour work or on some simple geometrical pattern or part of any design. The design seen will make, with its reflections in the mirrors, very beautiful symmetrical figures. Vary the angle between the mirrors and note how the

slightest movement affects the resultant design. Next, raise the mirrors a fraction of an inch above the table, so that the design can be moved about, and you will get a wonderful series of changes.

The usual form of kaleidoscope is tubular, as illustrated by Fig. 113, *c*, *d*, and consists of two or three long, narrow mirrors of the same size arranged longitudinally inside the tube to include angles of 60 degrees. At one end is an eyepiece, at the other a flat object-box containing a number of transparent objects—usually pieces of variously coloured glass. Revolving the tube causes the objects to group themselves in different ways, each change giving a new design. From a mathematical point of view, it is interesting to consider the enormous number of groupings obtainable with a comparatively few objects. Thus, if only twenty be used, and a change be made every six seconds, it would, theoretically, be possible to continue changing at this rate for over 450,000,000,000 years without repeating any one design; and even twelve pieces would require constant work for ninety years!

A cylindrical tube is not essential, as a box of square section—say, 2 in. on the side and 8 in. long—answers well enough; but the mirrors will not mutually hold one another in position, so must be secured in some other manner.

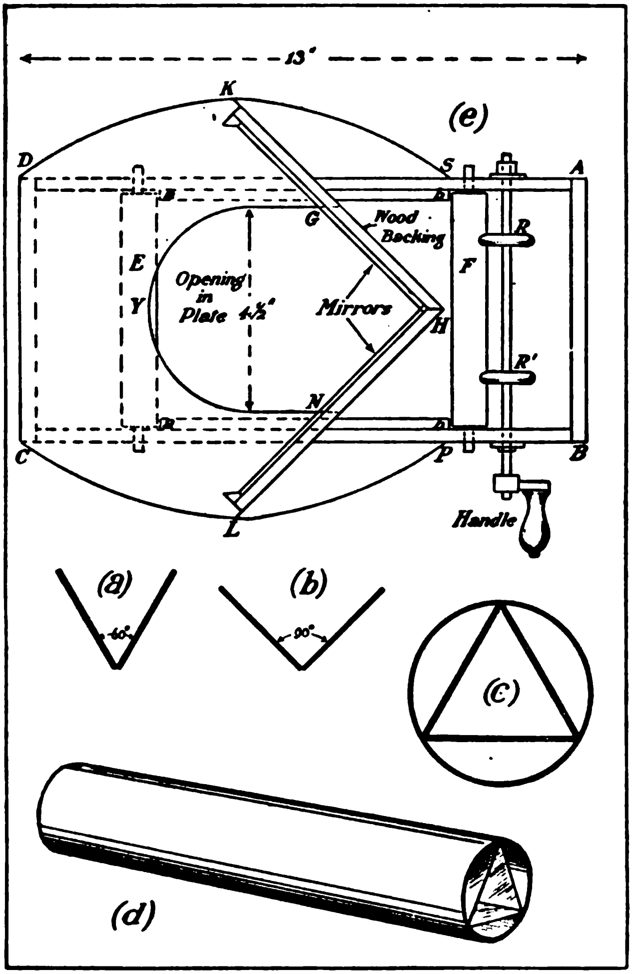

Fig. 113.—Details of kaleidoscope. (*a*, *b*) Mirrors arranged at angles of 60° and 90°. (*c*, *d*) Three mirrors in tube. (*e*) Plan of kaleidoscope.

A FIXED-MIRROR APPARATUS.

An alternative form of kaleidoscope, and one which provides the main subject of this chapter, has the mirrors fixed, and the objects moved past them by mechanical means. This type produces quite as beautiful and even more startling effects than the rotary, and possesses the great advantage of amusing a number of people at the same time.

Its general principle is as follows: The base is a long box stood on end, with the upper end removed. Inside the box are a number of rollers, two of which are almost flush with the top of the box, round which runs an endless belt of paper or some other material, carrying on the outer side the designs to be viewed. Two mirrors are arranged vertically on the top of the box, in contact at one edge, and at right angles to each other. The belt moves in the direction of a line bisecting the angle between the mirrors.

If the rollers be revolved and the belt set slowly in motion away from the angle, the figures appear to be coming out of the point where the mirrors meet, and to spread in all directions. If, on the other hand, the motion is towards the angle, the figures contract as they approach the angle, and seem to disappear at the point of junction.

Figs. 113, *e*, and 114 are working drawings of a practical apparatus, which can be easily made, and

is something more than a toy, though it will greatly interest and entertain children in a more instructive manner than does the ordinary instrument.

The dimensions given, taken from an apparatus designed and made by the writer, need not be adhered to strictly, though the *proportions* may well be observed, whatever the general size adopted.

The Mirrors.—These should be as thin as is consistent with good quality. Ordinary thin common mirror glass *may* be used, but it is inferior to what is known as "patent plate," which any good picture-frame maker will supply. One may select two mirrors, 6 in. square, and not more than ⅛ in. thick. The silvered side should be varnished and covered, while sticky, with strong paper, which is allowed to dry in contact to serve as a protection to the metallic film. (It is inadvisable to purchase *old* plate mirrors, as the deposit on these is often full of small holes, which will degrade the quality of the results.) The glass surfaces should be carefully cleaned and polished with a warm, clean duster.

Framing the Mirrors.—The supports for the mirrors are two pieces of ¼-in. oak or walnut, 6¼ by 6⅜ in. A 6¼-in. edge of each is bevelled off to an angle of 45 degrees (Fig. 113, *e*), and the two pieces are glued together at right angles to each other.

Along the top and outside edge of each is glued a strip of wood ¼ in. wide, and as thick as the mirrors. The last should have the edges which

come into contact at the angle blacked before they are put in position. Note that neither of the contact edges should overlap the other, but touch it, as shown in Fig. 113, *e*, a tiny space of square section being left in the extreme angle.

The mirrors are secured in position by narrow strips of black gummed paper—lantern slide strips are very suitable—adhering partly to the frame and partly to the mirrors ; or very thin strips of wood may be used for the same purpose.

The Box.—The box on which the mirrors rest is 18 in. high, 6 in. wide, and 13 in. deep from back to front. Fretwork wood may be employed in its construction. It is advisable to screw the parts together, so that any one may be easily removable.

The box and mirrors are shown in Fig. 113, *e*, as seen from above, and sideways in Fig. 114. The portions S K D S, P C L P (Fig. 113, *e*) are shelves attached to the outside of the box, on brackets, and flush with the top edges, to assist in securing and protecting the mirror supports.

An aluminium plate, G K D C L N Y G, covers part of the top of these shelves, and extends under the edges of the mirrors from K to G and L to N. It also covers in part of the top of the box, the opening G Y N H being left to display the band of designs passing immediately below the plate round rollers F and E.

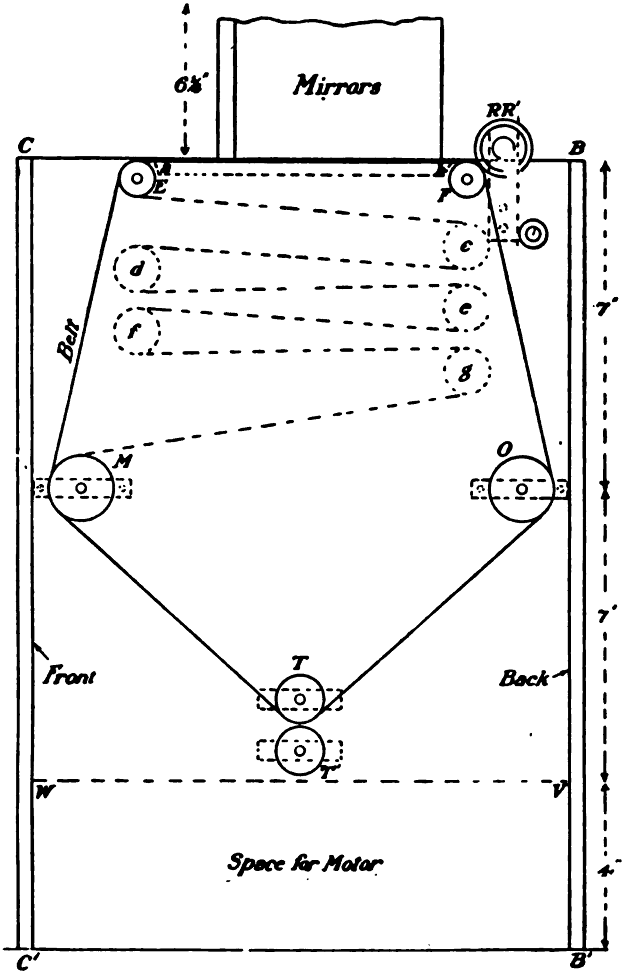

Fig. 114.—Side elevation (sectional) of kaleidoscope.

The last are $\frac{3}{4}$ in. or 1 in. in diameter, pivoted on pins passing through the sides of the box, and so situated that their highest points are not quite flush with the top of the box. The endless band of designs must just clear the under side of the aluminium plate. If the band should tend to sag between the rollers, it may be supported underneath by removable parallel rods, arranged at convenient distances from the rollers.

R and R^1 are two metal or wood pulleys, fitted with rubber umbrella rings, and both fixed to a spindle rotated by a handle. The spindle turns in plates on the outside of the box (see Fig. 114), which are so adjusted that the rings press the band tightly enough against the roller to get a sufficiently strong grip on the band to move it.

M T O (Fig. 114) are rollers similar to E and F. The endless band passes round them as shown. Pulley T^1 is to prevent the belt, if it sags, coming into contact with anything in the bottom part of the box. The space W C^1 B^1 V is reserved for an electric motor and accumulators, should it be desired to move the belt mechanically instead of by hand. Since an electric motor runs very fast, and the belt should be moved very slowly to get the best results, the motor must be geared down considerably. A suggested method is as follows: Obtain the works of an old clock, and remove the mainspring and the escapement. The mainspring

spindle is soldered to its drum or wheel, as the case may be, and provided with a pulley. The axle at the other end of the train is connected to the motor. The mainspring pulley (which must, of course, be outside the box) is connected by a belt to another pulley on the spindle on which R and R^1 are mounted. The diameters of these pulleys may be so proportioned as to give a further gearing down. A free "jockey" pulley may be added to take up any slack in the belt.

To make it possible to drive the endless band in either direction, the motor should have "permanent" magnets, and the direction of the current from accumulators to motor be controlled by a reversing switch.

The Band.—The width of the band is about $4\frac{3}{4}$ in. To keep the band centred, two strips, *ab*, *ab* (Figs. 113, *e*, and 114), are glued to the sides of the box between the rollers.

Instead of an endless band and rollers, one may employ two spools occupying the positions of M and O (Fig. 114), and each provided with a handle wherewith to wind the band from one to the other. To prevent slackness in the band under these conditions, each of the spools should be controlled by a simple frictional device which will make it turn rather stiffly.

Should the endless band be preferred, and its length be great, more rollers can be employed and

arranged at *c*, *d*, *e*, *f*, *g*, as indicated by dotted circles in Fig. 114. The belt will then zigzag to and fro across the box.

Transparent Bands.—The most beautiful effects are obtained by using a transparent celluloid film on which have been photographed designs previously drawn in black ink on white paper. The negative thus obtained shows the designs as transparencies on a black background.

The transparent areas are coloured with the pigments used for lantern slides. If the designs be painted on to the film, all the background must be "blocked out" with opaque paint, to confine the lighting to the pattern. This method is somewhat elaborate and tedious, but the results amply repay the labour expended on their production.

The transparency is lit from underneath by a four-volt electric lamp placed some 3 or 4 in. below the film. The apparatus in this case is, of course, shown in a darkened room, and the changes of the designs can be seen at a considerable distance.

Note that the band, of whatever material it be, should not be at all taut round the rollers; this applies especially to one of celluloid.

Designs.—The various designs on a band should be fairly close together, not more than ¼ in. separating each from its neighbours. Begin with very simple designs, such as circles, ellipses, 8's, 3's, S's, spirals, etc. Then proceed to more ambitious

outlines—simple drawings of birds, insects, animals, etc., of the conventional type found on ancient Egyptian and American monuments. Tattooed figures give very weird effects. To sum up: test everything by the method described on p. 373, and try all kinds of ideas that may occur to you. You will soon find out what is likely to be suitable.

Colouring.—The colouring—a most important point—should be as vivid as possible, because some of the original brilliancy is lost in the reflections. As to the harmonizing of colours, one should bear in mind that deep red harmonizes with a mixture of equal parts of blue and green; bright red with blue-green, green predominating; orange-red with blue, indigo; yellow with violet and indigo in equal parts; greenish-yellow with pale violet; and green with deep violet. Almost any combination of colours, however, produces a good effect, provided that it shows sufficient contrast.

Angle of Mirrors.—It is well to note that, if the mirrors be 90 degrees apart, the patterns produced by a kaleidoscope just described are always symmetrical. If the angle be 60 degrees, the patterns become more complicated, and the reflections do not in all cases join on to one another properly. The smaller the angle between the mirrors, the more complicated is the resulting design.

Chapter XXII.

APPARATUS FOR TESTING QUICKNESS.

Catch-me-quick—A Gramophone Whirler—A Mechanical Racecourse.

CATCH-ME-QUICK.

THE very simple piece of apparatus (Fig. 115) to be described is capable of giving a lot of fun, and of testing individual quickness, as the factor on which it is based is the speed with which the muscles of the hand will respond to the information given by the eye.

Materials Required.—A piece of board 1 in. thick, 16 in. long, and 4 in. wide; a lead or brass weight of from 1½ to 2 ounces; a piece of fairly stout clock spring; some whipcord; and a piece of very hard wood ¼ in. thick.

Principles.—A weight attached to the end of a piece of cord is allowed to fall, pulling a bead at the other end of the cord over a graduated scale. The game consists in releasing, by means of a trigger, a strong spring which nips the cord and arrests the weight instantaneously. The score is

decided by the distance which the bead has travelled from the starting-point. Two persons are engaged, the "letter-go" and the "catcher."

The Board.—Draw a line down the centre of the board, and at one end of it make a deep notch in the edge with a file, and smooth it with fine emery cloth. Half an inch back from the notch drive in a 1 in. staple, straddling the line. Near the other end, on the line, bore a conical hole with a countersink (used for letting screw-heads in flush). If you wish to make the board look smart, stain it with walnut stain and polish it. The apparatus will be more compact if arranged to fold at a point 9 in. from the notch end. Use what are known as desk hinges; and be sure to cut the board squarely across at the folding line.

The Scale.—This is a piece of stout paper or thin white card, an inch wide and a foot long. A quarter of an inch from the notch end draw a line halfway across it, and opposite this write the figure 0. Nine similar lines are drawn, the intervals decreasing from 1¼ in. by $\frac{1}{16}$ in. successively, so that a space of only ¾ in. separates 9 from 10. This system of graduation makes some allowance for the increasing speed of the weight as it falls. The scale is stuck, or nailed with small brass tacks, to the board along the centre line, the 10 end being close to the conical hole. If the board be a folding one, the scale must be neatly cut across at the joint.

push into it a loop of wire with the ends turned outwards. This can be suspended on a wire crossing the mould while the metal sets. File or scrape the outside smooth and bright.

The Cord.—For this one needs whipcord, as common string would soon be frayed by the spring. A piece 6 in. longer than the board will be sufficient. Tie a knot 2 in. from one end, thread on a brass bead large enough not to pass through the staples, and tie another knot close up to it. The spare tail will be handy for drawing the cord into position.

The other end is passed through the staples and secured to the weight.

If white or light-coloured cord be used, make an ink mark on it 4 in. from the spring when the cord is " set " with the bead in the hole; if dark-coloured, the mark should be made in white paint. This mark is to enable movement of the cord to be detected more easily.

Playing.—The board is laid on the table with the trigger end projecting far enough beyond the edge for the weight to clear the table or tablecloth.

The "catcher," whose quickness is being tested, raises the spring by the free end, pushes the trigger under it, and lets the spring down on the trigger.

The "letter-go" then pulls the small bead towards the other end of the board and holds it in the depression beyond the figure 10 by laying a

finger tip on it. His other hand is used as a screen to prevent the actual release of the bead being watched.

The string may be let go at any moment after the catcher says "Go!" The score of any round is reckoned by pulling the string taut while gripped by the spring and taking the figure nearest to the weight side of the head. Exactly halfway counts as the lower figure.

The catcher must not reset the trigger before the score has been called. Penalty: loss of any points scored that round.

If the trigger be released before the cord has moved, the player loses 10 points.

Ten rounds (maximum score, 100 points) constitute an innings for one player.

Playing by Sound.—If the simple little release shown in Fig. 115 be constructed, the game can be played blindfolded, the "catcher" using his ears instead of his eyes.

The release is in two parts: (1) a base piece, 4½ in. long and ¾ in. wide, with the two side wings drilled and turned up to serve as supports in which (2) the trigger works. The latter is weighted with a piece of sheet lead riveted on to the top side. An inch of wire nail soldered to the under side makes a suitable pivot.

A hole is drilled in the base of the same diameter as the top of the countersink—with which it must

coincide—and is situated under the pivot end of the lead weight.

The release is held to the board by two brass tacks engaging with slots in the base. The slots are made by drilling holes rather larger than the tack heads, and extending them laterally (in the direction away from the weight end of the board) with a watchmaker's file a trifle thicker than the shanks of the tacks. The release is passed over the tacks, and secured by turning a small button screwed to the board.

The bead is easily set if the string be brought under the turned-over part of the base and drawn round inside it, the trigger being simultaneously raised by depressing the tail.

The "letting-go" should be done smartly, to produce a decided and very audible click.

Catch-me-quick Cricket.—If one wishes to play cricket with the apparatus, a certain figure is selected as zero, and the player is "out" if he allow the bead to pass that figure. It is advisable to choose a fairly high number, 4 or 5, and to deduct that number from all those above it. Thus, if 4 be taken, 10 counts as only 6, 9 as 5, and so on. The spaces below the zero can be assigned to "bowled," "l.b.w.," "caught," "run out," and "hit wicket."

It is, of course, a very simple matter to prepare a special scale which can be pinned to the board over the other.

A GRAMOPHONE WHIRLER.

Get a circular cardboard box, 6 or 8 in. in diameter, and divide it into eight equal sectors by cardboard divisions, glued in place. Paint every other compartment a distinctive colour—blue, black, red, orange. The alternate divisions are left white.

The divisions should be cut away for half an inch or so at the bottom, where they meet, and a hole be made in the centre of the bottom to allow the box to be slipped over the central pin of the revolving table of a gramophone (Fig. 116).

Peas or some other suitable small objects should be dyed with the colours used for the box compartments.

Each of the four players is given a certain number of pellets, which have to be dropped, as the box revolves, into the compartment of corresponding colour. Every pellet that falls right counts a point; pellets in white compartments do not count; while pellets of the wrong colour score 2 each to the player into whose compartment they fall.

The difficulty of the game is regulated by adjusting the speed control, to make the revolutions quicker or slower.

A more exacting version of the game is obtained by fitting a lid to the box, and cutting in it holes an inch in diameter, one over each coloured compart-

ment. The top of the lid is divided up into sections, and painted to match the compartment below, and provision must be made for ensuring that the lid

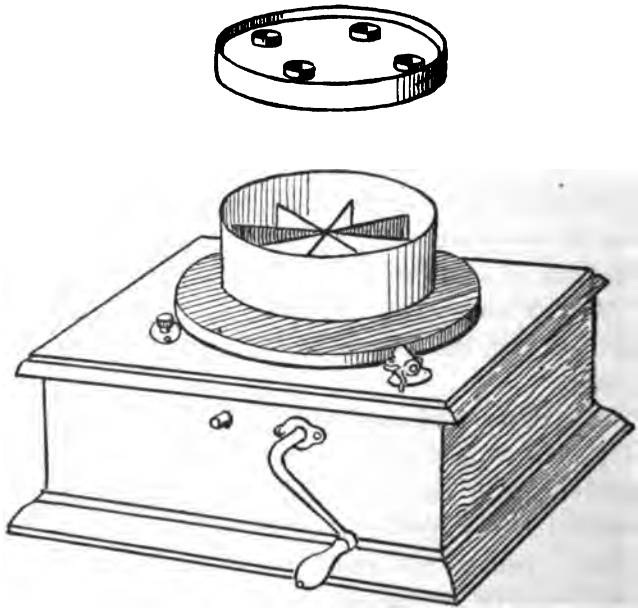

Fig. 116.—A revolving box with compartments into which coloured beads, etc., are dropped. Above is a lid with holes, which may be used to make the game more difficult.

when put on "corresponds" with the box (shown at the top of Fig. 116).

To prevent the pellets which do not pass the holes being flung off by centrifugal force, attach a rim an inch high to the circumference of the lid;

while the holes should be protected by ⅛-in.-high rims, that pellets may not roll or bounce into them off the lid. It requires very good judgment to make a "possible."

Scoring as in the first case.

A MECHANICAL RACECOURSE.

This little mechanism described is easily made at small expense, and is warranted to give a lot of amusement. It consists of a board along slots in which two or more model racehorses are made to progress by turning handles at one end. Each handle operates a worm and wheel, the latter driving a reel round which passes an endless band fastened to the base of one of the horses. As the wheel moves forward only one tooth for each revolution of the handle, the progress of the horse is necessarily slow, and a course 2 or 3 ft. long gives plenty of scope for exciting contests.

A side view of the mechanism is shown in Fig. 117. The most important requisites are a couple of worms and worm wheels. The latter should be about 2 in. in diameter and have 50 to 60 teeth.

The worm, W, is mounted on a short shaft which passes through the front of the case and through a small bracket, P, screwed to the bottom. It is prevented from moving longitudinally by a collar, C, inside, and by the handle outside. The hole in

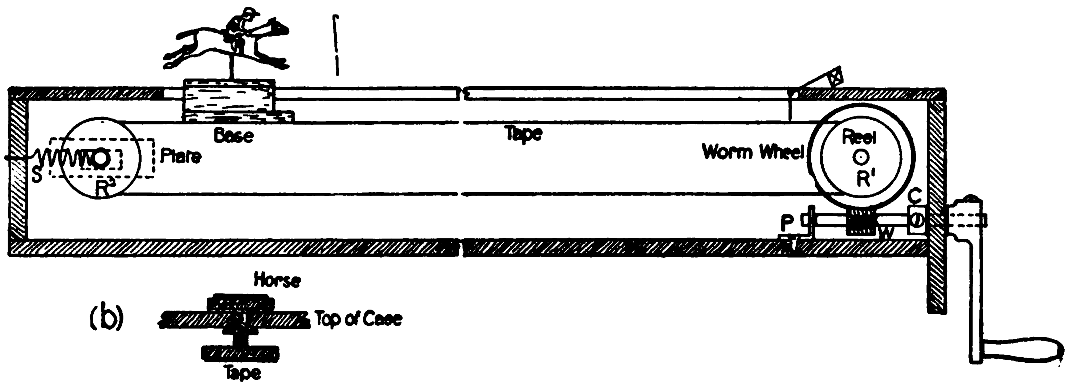

Fig. 117.—A mechanical racecourse.

the case should be lined with a piece of brass tubing to prevent wear.

The wheel is attached by screws to a reel, R, of the kind used for silk, with flanges about $\frac{1}{8}$ in. deep. It and the reel are mounted loosely on a fixed rod traversing the case, and kept in position by collars. If the reel hole be larger than the rod, wrap a few turns of thin paper round the last to improve the fit. Near the other end of the casing is a second rod carrying the "idle" reel, R. This rod moves in slotted plates fixed inside the casing, and projects half an inch or so at both ends. It is drawn towards the back of the case by a couple of springs, S, inside to keep the endless bands taut. The bands are of tape almost as wide as the reels, and when new should be of such a length as to bring the rod to about the middle of the slots.

The model horses are fixed to bases, the bottom flanges of which are glued to the bands. The "web" of each base works in a slot in the top of the case, and is prevented from sinking by the top flange, and from rising by a pin. A cross section of the arrangement is shown in Fig. 117, *b*. To set a horse at the starting-point, press its end of the rod forwards, to slacken the band sufficiently to allow it to slip easily over the wheel reel.

At the winning-post end of each slot is a little flag which is raised as soon as the base of the horse strikes the tail at the bottom of the wire on which

it is mounted. The flag which begins to rise first indicates the winner.

The worms should be at least 18 in. apart, to give performers plenty of room. In a two-horse apparatus place the worm wheels next to the sides and the driven reels inside them. Weight will be saved if the bottom, aft of the plate P, be left open. The front extends an inch below the bottom to hook over the edge of the table and prevent movement.

The course may be divided by cross lines to indicate furlongs or hundreds of yards and handicapping marks. Blacklead the contact faces of the horses' bases and the sides of the slots to reduce friction to a minimum.

If a very long race be desired and the case is to be kept short, the worm wheel should be attached to a small pinion engaging with a larger pinion on the driving reel.

Model university racing boats or motor cars may be used as alternatives to horses, the cars being attached in such a way that the wheels run on the top of the board. To save the models from damage when the board is not in use, each should be provided with a removable cover; or this may be hinged to the board and thrown back when a contest is about to take place.

Chapter XXIII.

ELECTRIC BELLS AND ALARMS.

How an Electric Bell works—Batteries—Wiring—Installing a Bell—Tracing Faults—Double and Multi-bell Circuits—Indicators—Burglar Alarms—Arrangement of Alarm Circuits—An Alarm for the Front Door—An easily made Relay—An Electric Clock Alarm.

THIS chapter is devoted mainly to hints on connecting up electric bells and keeping them in order. At the end instructions are given for making a few useful fittings.

Any reader who is ignorant of the working principles of an electric bell should consult Fig. 118, which shows diagrammatically the parts of such a bell, and its connections with battery and push. When the bell-push is pressed in, current flows from the battery to one terminal, T^1, of the bell, through the windings of electro-magnet M, through flat spring S, and insulated pillar P, to the other terminal, whence it returns through the push to the battery. There are thus six terminals to be connected up "in series," battery to bell, bell to push, push to battery. When the circuit is closed

and sealed at the top); (2) an outer glass jar in which is (3) a zinc rod, the positive element (Fig. 119, *a*).

To charge the battery, sal ammoniac is dissolved in water in the proportion of two ounces to the pint, and poured into the outer jar till it reaches up to a black band on the inner pot.

The sal ammoniac finds its way through the pot to the carbon in a few hours' time, and the cell is ready for use. As the zinc is affected by the sal ammoniac only when the bell is ringing, recharging of the cell or replacement of the zinc rod is required only at very long intervals.

The zinc rod should be "amalgamated" before use by dipping it in a solution of sulphuric acid, and rubbing it over with a little quicksilver applied with a piece of washleather tied to the end of a stick.

If two or more cells, whether wet or dry, have to be connected together to get a stronger current, it is usual to join the zinc of one cell to the carbon of its neighbour, leaving the end zinc and carbon free for connection with the circuit wires. This method, known as connecting up in "series," gives a current with a pressure or voltage equal to the sum of the pressures of the separate cells (Fig. 119, *b*).

Another way is to join the cells in "parallel," all zincs together and all carbons together, and

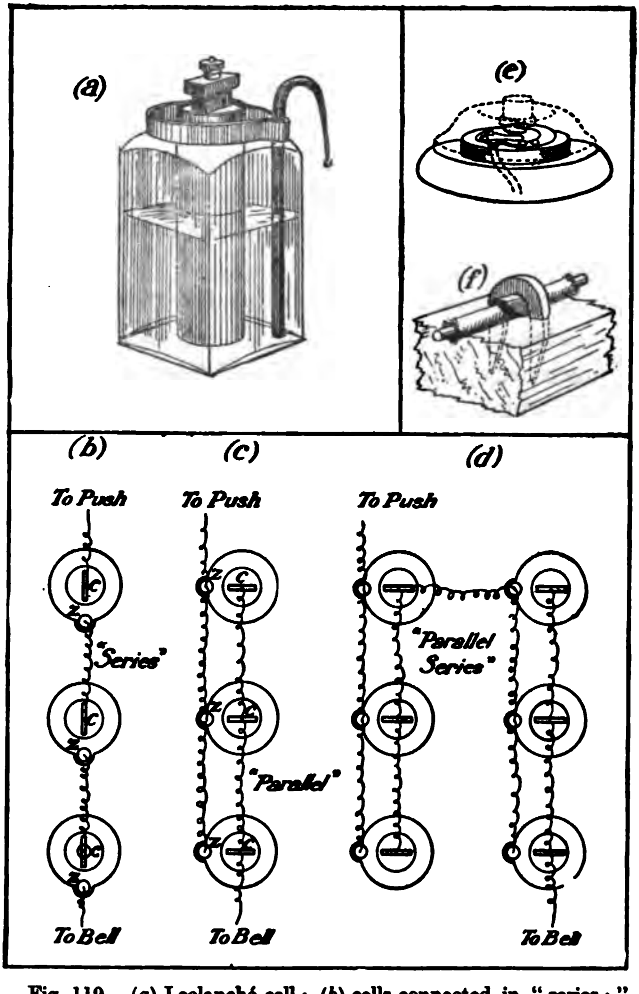

Fig. 119.—(*a*) Leclanché cell; (*b*) cells connected in "series;" (*c*) cells connected in "parallel;" (*d*) cells connected in "parallel series;" (*e*) bell-push for electric bell; (*f*) protected staple for fixing insulated wires.

each group to one of the circuit wires. This "parallel" system (Fig. 119, *c*) increases not the pressure but the quantity of the current, so that if three cells are thus coupled they are in effect one cell three times as big as any single cell of the group.

Series connection is useful for overcoming the resistance of a long circuit; parallel coupling is much used where a number of pushes operate one bell which is often rung. In some cases a combination of the two is advisable, groups of cells in parallel being connected in series (Fig. 119, *d*).

A word of caution is needed about cells connected in series. If one of them become exhausted, it acts as a strong resistance and reduces the efficiency of the others; whereas, if a unit of a parallel group fail, the group is merely robbed of that unit's contribution. Also, cells in series should all be of the same capacity.

Wire.—The cheapest grades of insulated wire are to be avoided, as likely to give trouble. For single-circuit installations "twin" wire, with two wires separately insulated, but laid side by side (not twisted) in a common insulating cover, will be found most convenient. In a more elaborate installation it is advisable to use single wire throughout, reserving one colour—say blue—for all leads to one battery terminal and other colours for the leads running to the bell. (See Fig. 120, *a*.) This

makes it impossible to get the connections wrong, if blue be connected to blue throughout.

Joining Wire.—Many of the troubles associated with electric-bell work may be traced to imperfect contact at joints in the wire. If two pieces of wire have to be connected, burn off the insulation for a couple of inches, scrape the wire bright, twist the ends spirally round one another, and *solder* them, using powdered resin as a flux. Then bind the exposed parts carefully with insulating tape. A joint of this kind never gives trouble; one made by merely twisting the wires often does.

Installing an Electric Bell.—The first pull-bell to be replaced by an electric is, in the majority of cases, that serving the front door; so in the following paragraphs we will assume this to be the case. The first thing to do is to decide how the wire is to be run from the door to the kitchen or other part of the servants' quarters where the bell will be situated. If there be cellars under the house, the simplest course is to carry the wires down into them from the push, along the joists, and up to the bell—two holes only being necessary in such a case. In the absence of cellars, the track taken by the wires of old bells should, if easily accessible by the removal of boards, be used. As a last resort the wires must be carried along angles where they will be least obtrusive and not interfere in any way with traffic.

Having decided upon the course, measure off the distance, using a piece of string if there be many twists and turns, and order wire accordingly.

Special contacts are sold for use in connection with ordinary bell pulls; but in most cases it is most satisfactory to remove the pull and replace it by a push fitting the space left vacant by the pull-plate. Or the bell knob should be removed and a push screwed to the door frame or central stile of the door itself. The twin wire is passed through the hole made for it, bared for an inch or so, and scraped bright. The end of each wire is then bent into a neat loop, and attached to the push by one of the screws intended for the purpose; and if there seem to be any danger of its making contact with the other, it is carefully insulated with thin wrapping tape. The push is then drawn back by the wires into place and secured with screws.

The running of the wires may then be taken in hand. If the push be on the door itself, the wire must be wound round a small rod to form a spiral at the point where it passes the hinge, so as not to be broken by constant bending; or be made fast by a staple on the door-post.

Stapling Wires.—Staples should not be driven in at all tightly until the wiring has been completed, all slack taken up, and connections duly made. To prevent the staples breaking through the insulation or injuring the wire, it is well to interpose

between them and the wire half-inch lengths of small rubber tubing, slit longitudinally to pass over the wire. This will necessitate the staples being somewhat larger than the wire. Special staples with fibre insulating pieces are sold for the purpose (Fig. 119, *f*).

The Use of Wire Tubes.—The zinc tubes often used as runways for pull-bell wires may come in useful for housing electric-bell wires. The mechanical wire should be cut off, and hooked or otherwise attached firmly to the electric wires to draw them through the tube. The same advice applies to getting electric "leads" through holes in walls, floors, etc.

Connecting up.—If a wet Leclanché cell be used and the wires pass through a cellar, the battery may be placed there, out of the way. To couple-up the battery, bare *one* of the wires for a few inches, cut it, and attach the ends to the battery terminal. The twin wire is then carried on to the bell and connected to its two binding posts (Fig. 120, *a*).

If the battery be beyond the bell, the connections are as in Fig. 120, *b*.

At all terminals the wires should be scraped clean and the screws made tight. The carbon terminal of a wet cell should be thickly smeared with vaseline to prevent corrosion by fluid "creeping" up.

Tracing Faults.—If the bell refuse to ring when the push is pressed home, the following steps should be taken in order till the matter is put right :—

1. Examine all connections, and clean or tighten any that seem to require attention.

2. Connect battery to bell by short pieces of wire. If the bell will not ring—

3. Borrow, if possible, a bell and battery known to be in working order, and cross-couple them—old battery to new bell, and *vice versa.* This will show which is at fault.

4. If the battery be the culprit, replace it, if of the "dry" order, by a fresh cell; if "wet," get a new carbon element and zinc rod—assuming the latter to be much corroded—and re-charge with sal ammoniac, "amalgamating" the zinc as already described.

5. If the bell be at fault, examine the platinum contacts, and clean them if dirty; see that the platinum-tipped screw is properly adjusted; examine the connection of the magnet bobbin windings, made by twisting the bare ends of the wire together. If solder has not been used, oxidization may have led to imperfect contact.

6. Go over the wire circuit carefully, looking for possible damage by the staples. As a last resort notch through the insulation of each wire on opposite sides of the wrapping, and short-circuit

the wires. If this be done systematically at intervals, beginning at the push ends, the trouble will

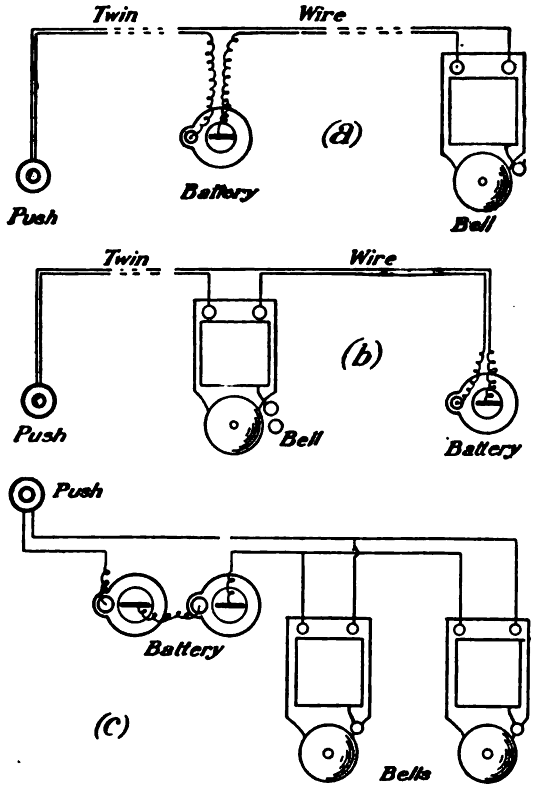

Fig. 120.—Electric-bell connections.

be located, and it only remains to fix fresh wiring between the point where short-circuiting makes the bell ring and the push, unless the fault can be

definitely located, in which case a short piece of sound wiring should be inserted and soldered.

An ordinary 4-volt voltmeter, such as many motorists use, is invaluable for testing batteries and circuits. Failing this, a small galvanometer, which can be bought for a shilling or two, is useful.

Double-Bell Circuits.—Fig. 120, *c*, shows the connections when two bells are worked by a single push or any one of a series of pushes on the same circuit.

This arrangement requires for its satisfactory working that both bells should be of the same or very nearly the same pattern, so that each shall absorb only its fair share of the current. The battery power should be double that used for a single bell.

Several Pushes on One Circuit.—Fig. 121, *a*, shows diagrammatically the connections from several pushes to one battery and bell. Where only a limited number of rooms are connected up to the bell this system acts very well, as a simple "code" can be adopted, which will be understood from any point at which the bell is audible; whereas if an indicator be relied on it must be consulted.

A blue wire is run from the farthest push, which we may assume to be that on the front door, to the battery, and a red one to the bell. Every other push has a blue wire in connection with the

"through" blue, and a wire of some other colour joined up to the "through" red, soldering being used at all joints. If more convenient, any other

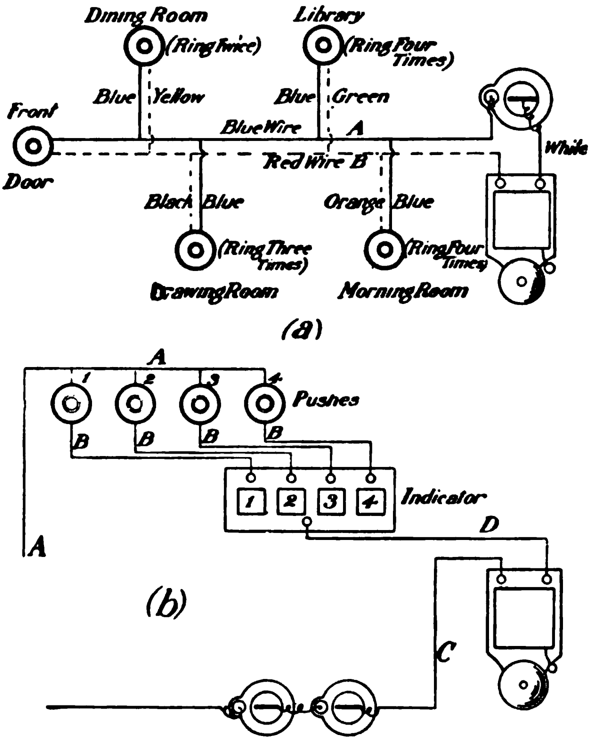

Fig. 121.—Electric-bell connections.

push may be made the outer end of the "through" wires. Should one of the pushes be quite near battery and bell, a separate connection to them may be simpler than joining up.

Indicators.—These may be either of the pendulum type, which causes a small pendulum to swing under the name of the room which has rung up; or of the mechanical type, which displays a red signal at one of the little windows in the indicator front. The second kind is furnished with a knob, which the person who answers the bell presses in to "clear" the window. Fig. 121, *b*, shows the connection. In this case there may be a single common trunk wire, A, to the battery; but each push must have its *separate* return wire, B, to the indicator. The wires C and D connect the bell to the battery and indicator respectively. The current passing from bell to push has to traverse the windings of a magnet in the indicator and attract an armature which swings a pendulum or releases a signal disc, as the case may be.

BURGLAR ALARMS.

The electric bell is one of Bill Sikes's greatest enemies, as a proper installation makes it impossible for him to open any external window or door in a house without rousing the household. Such an installation must include a powerful continuous-action bell, which, when once started, goes on ringing until switched off, thus ensuring that it attracts attention. The bell is provided with a trigger (Fig. 122, L), which is released by the first motion of the armature and closes a switch which puts the battery and

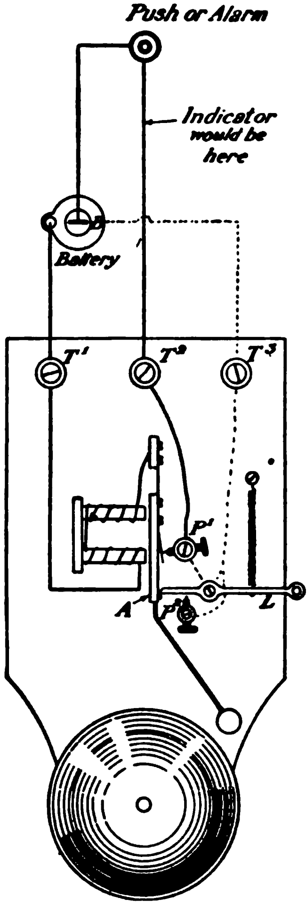

Fig. 122.—Continuous-action electric bell.

bell in circuit independently of the alarm push circuit.

Every sash window which is likely to be a point of entry should have an alarm let flush into the inner sash grooves near the bottom, and into the outer near the top, so that neither sash can be moved more than an inch or two without releasing the knob, and allowing a spring to make contact with a plate and close the circuit. Alarms of much the same kind are sold for French windows and doors.

All downstair windows and outside doors should be thus protected, as well as windows on landings and in upstair rooms not used at night. If bedrooms be included, their connections should be provided with switches, so that the windows

of occupied rooms may be left open for ventilation.

Arrangement of Alarm Circuits.—The bell will be placed in or near the bedroom of the master of the house, whose business it is to close the main switch when retiring for the night. This switch should be in a place where the servants can get at it to open it in the morning.

The system of wiring may include a main "through" line and branches to the various alarms, and generally resembles that for bells given in Fig. 121, *a*. One should note, however, the secondary connection (dotted lines) between battery and third terminal (Fig. 122).

In a small house an indicator is not necessary, as the noise of the bell would quickly awaken all the inmates and scare off any marauder. In a large house, on the other hand, an indicator might be of value to locate the alarm exactly, or at least to show from what part of the house the warning proceeds. This requires that each room, or group of rooms, shall have a separate return wire running to the indicator, interposed between alarm and bell. (See Fig. 121, *b*.)

A Simple Burglar Alarm for the Front Door.—A small flat tobacco tin with a hinged lid, such as is used to hold 4 oz. of a certain brand of Navy Cut tobacco, makes a good case for this apparatus.

The alarm or automatic switch consists of a

small block of wood and an ordinary lock spring (price about one penny). The spring is attached to the block by a screw, V (Fig. 123, *b*), and is kept partly expanded by two screws, W and T, driven into the wood. These two screws have soldered to them the two wires of the bell and battery circuit.

To one arm of S is tied a cord or wire passing through a hole in the box—as do the line wires—and terminating in a hook which, to set the alarm, is engaged with an eye on the door protected. The cord is of such a length that when the door is closed S is drawn away from T, and the circuit broken; but it ensures that S shall touch T before the door has opened far enough for an intruder to enter.

The alarm is secured to the bottom of the box by a couple of screws. The bell wires must be carefully insulated at the point where they pass through the metal; otherwise a short-circuit and a false alarm may result.

The box, after being painted to match the neighbouring woodwork, is fixed to the wall at about the elevation of the top of the door, where the string will be out of the way. It must be so arranged that the string or wire has a straight pull through the hole made for it.

An Easily Made Relay.—The alarm, instead of being in direct circuit with the bell, may be assigned

its separate battery, and be made to operate a "relay," which closes a second circuit in which is the bell, and causes the bell to go on ringing until the relay is opened again. The relay serves, in effect, the same purpose as the device shown in Fig. 122 for making a bell ring continuously. As the relay would naturally be placed somewhere out of the burglar's reach, he would have no alternative to retiring hastily after receiving audible evidence of having raised the alarm.

Fig. 123, *a*, is a plan of the relay and its connections. It should be stated that the apparatus is vertical, just as it faces the reader, if he hold the page upright.

The principal parts are a wooden base, to one corner of which is screwed a smaller block, K; a magnet, M, made by wrapping insulated wire round a large carpenter's screw; and a little piece of brass, D, attached to the end of a pivoted arm, G.

Just in front of the magnet, and about $\frac{1}{32}$ in. away, is an armature, A R, of tin, pivoted at F, and prevented from going further to the left than is allowed by the pin E. When A R is vertical it will support D, if that be raised and let down on top. The raising of D brings G against A, and so brings the one alarm wire into circuit with the other *via* G, B, and the magnet winding.

When the alarm closes, M attracts A R, and D falls on to C, so completing the bell circuit. At

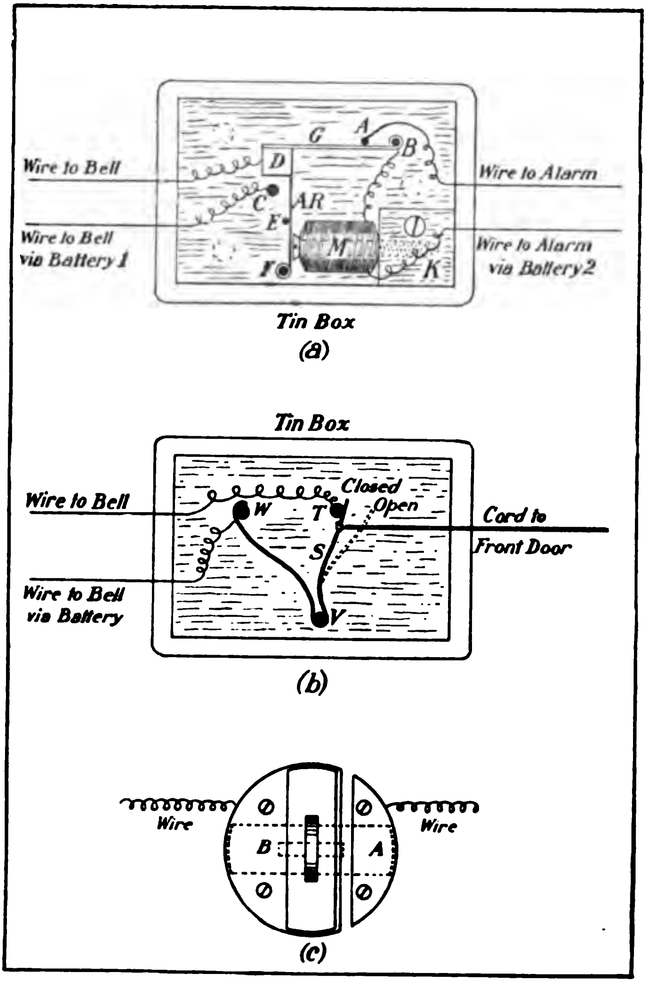

Fig. 123.—(*a*) Electric relay; (*b*) burglar alarm; (*c*) switch.

the same time the alarm circuit, which has already done its work, is broken, and the short-circuiting of battery 2 prevented.

The relay is enclosed in a tin box similar to that used for the alarm. Two short pieces of string should pass from G and A R respectively to beads outside the box, to enable the relay to be reset by raising G and pulling A R to the left.

A Disconnecting Switch.—To prevent the alarm operating the bell during the day, a switch must be included in the circuit. A very simple but effective switch can be made out of brass cupboard-turn of the kind illustrated in Fig. 123, *c.* The smaller part, A, should be so fixed that it does not touch the larger, B, on which is the turn-button, and be raised a little higher, so that the turn-button has to "climb" it and make a good contact. If the nearer edge of A be slightly bevelled off, closing the switch will be easier.

The two parts are screwed to a single block of wood, which is fixed in some convenient part of the house.

AN ELECTRIC CLOCK ALARM.

Fig. 124 represents a combination of electric bell and alarm clock. The alarm winding gear must have an external key, which revolves slowly when the alarm is ringing.

Make an L-shaped stand with a back as deep as the battery and bell are high, and wide enough to

take both comfortably; and a base deep enough to accommodate the clock. The bell is screwed to the back, and the battery—a dry cell—secured by

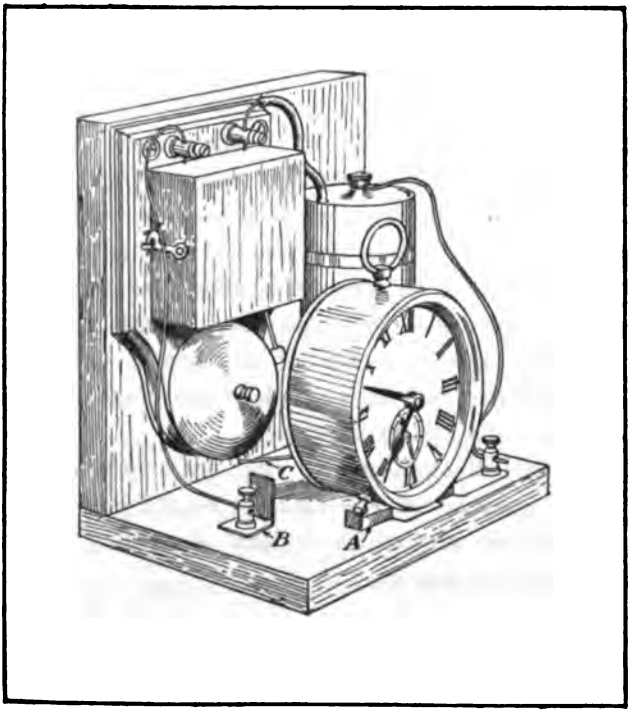

Fig. 124.—Electric alarm clock.

string passing round it at two points and through holes in the wood.

A is a trough of thin brass, with sides turned up one-eighth of an inch. It is half an inch deep from

front to back, and just long enough for the two legs of the clock to get into it. One end projects an inch or so to give room for a binding post.

Bend two inches of sheet brass an inch wide into an L, and drill one arm, B, for the second binding post. Unscrew the alarm winder, and at the end of a short piece of stout brass wire, C, make a loop which will grip the shank of the winder tightly. Now place the clock with its legs in the trough, and screw the binding post in a position where the end of the wire striker can reach it. Then connect bell to battery, battery to binding post, and bell to B. When the clock has been wound and the alarm set, raise the striker so that it does not make contact with B, and place the clock on the stand with its legs in the trough.

As the bell continues to ring until switched off by the removal of the clock from its stand, the person to be aroused is at least compelled to get out of bed to stop it.

Chapter XXIV.

DECORATIVE WORK.

Stencilling—Marquetry Staining—Pokerwork.

STENCILLING.

THIS form of decoration is as simple and cheap as it can be made tasteful and effective. The principle of stencilling is the application of colouring matter to a surface through openings in a card or plate so perforated as to give the pattern desired. The process is suitable for the execution of friezes and dadoes on the walls; for the patterning at intervals of the whole area of distempered or monotone-papered walls; for the decoration of door panels, cushions, curtains, tablecloths, and other objects which may benefit by simple coloured designs. In this article our attention will be confined to the stencilling of walls.

Stencil Patterns and *Plates* can be bought ready-made at house decorators, artists' colourmen, and some of the large London stores. The preparation of home-made plates is within the capacity of any careful worker.

For *material*, thick brown paper, Bristol board, thin cardboard, or the oiled card used in letter-copying books may be used. All but the last will be rendered more durable by being coated after cutting with knotting varnish.

Design.—The designing of original patterns is necessarily dependent on the skill of the worker. Unless he be already somewhat of an artist he should be content to use other people's designs at first, and to experiment with "detached" designs, as opposed to "running" or continuous, which are more difficult to handle.

The suitable *size* and *colouring* of a design are influenced by one another, also by the general surroundings; and exact principles cannot be laid down.

Good working rules are: (1.) The stronger the colour and contrast with the background, the smaller should the design be. (2.) Large designs require soft colouring. (3.) Colours should harmonize with the background. (4.) Neutral backgrounds are best to work on.

The safest procedure is to transfer the pattern to a sheet of paper of approximately the same colour as the background, colour it, and place it in a position which the actual stencil will occupy. This will enable you to judge whether the proportions and colouring can be improved on.

Cutting Out.—Fig. 125 represents the stencil

plate of a "detached" design. This design was reproduced in black on a wall papered with brown lining paper—a very cheap but effective wall-paper, by-the-bye. It shows very clearly the ties or bridges which serve the double purpose of holding the parts of the design together and of giving the characteristic "interrupted" stencilling effect.

Fig. 125.—Stencil plate for detached design.

Ties must not be made too narrow. As a precaution against accidentally severing them by mistake when cutting out, it is wise to mark in solid colour all the parts which have to be removed before getting to work with the knife.

If duplicate plates will be needed, make a "master" pattern and trace from that on to the cards.

A very sharp knife is needed for the cutting out.

The resistance to a blunt knife tends to break the ties. Keep an oil-stone handy and touch up the edge frequently. A sheet of zinc or a glass plate should be under the card. Glass blunts the edge quickly, but cuts made against it are very clean. The edges of small apertures, especially in thick card, should be bevelled off outwards to allow the brush to get down to the wall.

Square off the finished plate accurately, and mark vertical and horizontal lines, crossing at the centre, to assist in placing it in the correct position on the wall.

Different Colours.—For a design which includes two or more colours, a separate stencil plate should be cut for each colour. In such a case it is advisable to colour the key design carefully beforehand. If the plates be squared accurately there is no difficulty in bringing them into register.

Marking Out.—The necessary guide lines and marks on the walls should be completed before stencilling is begun, as it is difficult to remedy mistakes afterwards. For a frieze or dado first get the horizontal line parallel to the cornice by means of a string stretched tightly half an inch above the actual line, which should be ruled in stick charcoal along a straight-edge. The charcoal leaves no stain when wiped off. Next, mark the centre line of each stencil at right angles to the base line. You will have to calculate beforehand

what distance between centres best suits the various lengths of wall on which the frieze will appear, since the spacing all round must be as consistent as possible.

If the whole area of a wall is to be stencilled, equidistant vertical and horizontal guide lines, crossing at the centre points of the plate, are needed. The spacing should be carried round an interrupted corner just as if the two walls were in

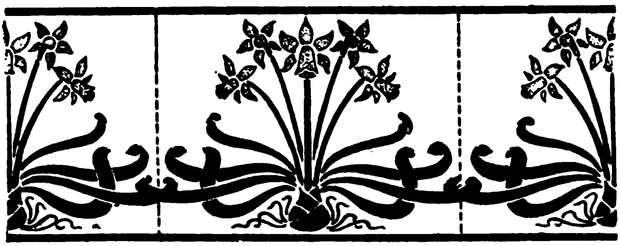

Fig. 126.—Running design in two colours for frieze.

the same plane; but arrange that the actual corner comes in a blank vertical space.

Colouring Matter.—Either water colour or oil colour may be used. The first is more easily applied, though more sensitive to damp. For *water colours* (which are practically distempers made with special care), dissolve some gum arabic or size in water, and add to it ordinary whitening and colouring (obtainable in powder form at any good oil-shop) to give the tint required. The liquid should finally have the consistency of cream.

Oil colours are composed of ordinary tube colours ground up with flake white in oil.

Mix in the first instance the full quantity of paint that you will be likely to require. It is almost impossible to match tints in subsequent mixings.

Brushes.—Special brushes with bristles cut square at the end are sold for the purpose.

Applying the Colour.—Fix the stencil plate in position with a couple of pins. The best pins for the purpose are those used by photographers, having points set in a small glass or metal handle.

Use as little colour on the brush as will do the work. Dab the brush *squarely* against the plate. On no account draw it along the design, as such a proceeding would scrape off an excess of colour, which would find its way under the plate.

Lift the plate smartly away from the wall: *avoid sliding* it along. A couple of tapes or knobs fixed to the plate make the lifting very simple.

Wipe the back of the plate after each application, as a precaution against smearing.

If two or more colours have to be applied, allow one to dry thoroughly before applying another. It will probably save time to go right round with one colour. On a big job it is a great advantage to have a trusty assistant to follow you round at a due interval of time with a succeeding colour.

Running Designs.—Fig. 126 is a running design in two colours for a frieze; Fig. 127 a running

design for a dado. The single recurrence of the design is indicated by the vertical dotted lines. Where the design is of a very simple character, as in Fig. 126, the plate may be made long enough to include the design twice; one repetition being "halved" as shown. If two stencil plates be used alternately, the design can be carried along continuously, one plate being lifted over the other. The colour bands top and bottom may form part of the stencil design or be put in separately. In

Fig. 127.—Running design in two colours for dado.

the first case the openings for the line must be tied at intervals (as shown by the broad white dotted lines in Fig. 127), and the areas covered by the ties coloured in afterwards.

MARQUETRY STAINING.

Marquetry, or Marqueterie, proper is the art of inlaying patterns in a sheet of veneer with small pieces of naturally or artificially coloured wood cut with a fretsaw from other sheets, the "ground"

and the "filling" sheets being clamped together during the fretsawing.

This work requires great care and skill with the saw, and makes considerable demands on the time. The effect of a well-conceived and well-executed design is very pleasing—witness the splendid examples in the Wallace Collection.

Marquetry *staining* produces somewhat of the

Fig. 128.—Marquetry clock stained.

same effect by means of transparent colours applied with the brush to a suitably prepared surface of white wood. The manufacture of these colours has reached a high pitch of excellence, and the variety of hues and tones obtainable enables the amateur to produce extremely effective decoration on articles of all sizes, from a small box to a large chest, table, or other piece of furniture. Mar-

quetry staining is especially suited for door, cabinet, and screen panels, placed in position when finished; and for landscape or portrait work, framed in the usual way. In short, being brush work pure and simple, it has a field as extensive as that of oil or water colour, allowing for the necessary limitations imposed by the fact that comparatively simple patterns and designs are more generally effective than those containing a mass of detail.

Designs.—Wooden articles are now sold in great variety, either plain or with designs ready impressed, for poker work or marquetry; as also books of designs which the worker may transfer by means of carbon paper, obtainable at any artists' colourman. The beginner will probably prefer to confine his first attempts to the prepared articles; and this course has the advantage that if anything goes wrong less time will have been wasted. The ambitious artist is, of course, anxious to originate, and so should take every opportunity of gathering ideas from the productions of experts to be seen at exhibitions and elsewhere.

The design may be white on a coloured background, or *vice versa*. No rules are possible, as the nature of the subject decides the treatment. Very tasteful work can be accomplished in plain black and white.

Materials.—An outfit includes bottles of stains and varnishes, a set of brushes—flat for back-

Fig. 129.—Box lid in plain black-and-white marquetry.

grounds and large areas, pointed for small spaces, and very fine for outlining—and sandpaper. A "Marquo" outfit, the stains of which are very high-class, and vastly preferable to the cheaper

aniline dyes, costs under a guinea, so that marquetry is essentially a cheap hobby so far as the apparatus is concerned.

Woods.—The best woods for staining are scyamore, chestnut, and lime. They must be entirely free from knots, as these form dark spots, which spoil a design; and well seasoned, so as not to warp under the action of the stain. Common pine may be used for large work of bold design, but it should be faced with thin size lest, owing to its porous nature, the stain should be absorbed unevenly and have a patchy appearance.

Preparing the Surface.—The surface, whether ready patterned or not, must be rubbed down with glass-paper—that of the very finest grain obtainable being applied last—until as smooth as it can be made. Be careful not to rub *across* the grain. If the pattern — we assume that the article is bought with it on—show signs of disappearing under this treatment, it should be incised with a very pointed knife-blade. (The depth of the marks should only be sufficient for them to be just visible when the sandpapering is finished.)

Some workers outline the pattern with Indian ink (Higgins's Waterproof is the best for the purpose) before applying the stains; others do the inking after the staining is complete. The first course has in its favour that it forms boundaries beyond which the stains will not travel if a moderate

amount of care be taken. It must not be assumed, however, that inking is necessary for all designs, or that, where used, an ink line must limit every coloured area.

Applying the Stains.—The background is taken in hand first. A flat brush is needed for the main part of the larger areas, and a fine-pointed brush for the edges. The three chief rules to be observed

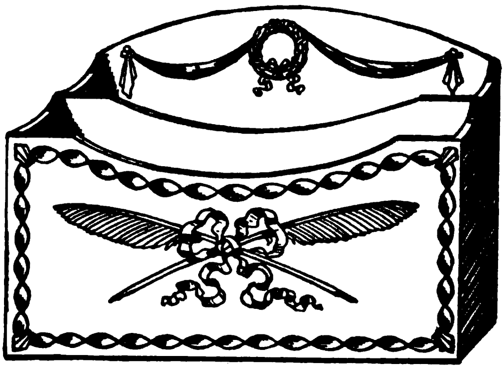

Fig. 130.—Marquetry stationery rack.

in brush work are: (1) Paint with the grain; (2) don't allow the edge of one stroke to dry before the second is applied—to avoid brush marks; (3) don't paint the surface twice. Depth of tone can be increased by exposing a few drops of stain until evaporation has concentrated the colouring matter.

When the background is finished, the design is taken in hand. So far as is possible, avoid having

two contiguous wet areas of different colours, lest the stains should "run." To save time, finish off with one colour before going on to a second.

Shading is effected, not by adding more colour, but by soaking out part of the stain by the application of a moistened brush. Therefore be careful to consider the darker tones in the first instance.

Setting.—The stains are sensitive to friction, and easily worn off in their natural dry condition. Therefore, as soon as the staining is complete, it must be "set" by the application of a coating of French polish with a round-ended camel's-hair brush, known as a "dabber." The polish forms a protective coat.

Finishing.—The article can be finished either (1) by varnishing or (2) by polishing.

Varnishing itself falls under two heads—(*a*) oil varnishing and (*b*) spirit varnishing. Whichever be used, it is essential that operations be conducted in a warm, dry, and dustless room; that several coats be applied (*with* the grain) as smoothly as possible; that each coat be well rubbed down and allowed to *dry* thoroughly before the next is applied. The rubbing down of an oil varnish is effected with pumice stone and water; of a spirit varnish, with the finest sandpaper and linseed oil. In either case the last coating may be of oil varnish.

The varnish protects the stain and builds up a "body" which, if properly rubbed down, gives a

much smoother surface than wood. *Unrubbed* coatings merely repeat irregularities of the surface.

Polishing may be conducted with (*a*) beeswax or (*b*) with French polish. The first is far the easier for the amateur to handle. Common beeswax, softened by heat, or thinned with turpentine, is rubbed in with a soft rag until the surface ceases to show the least sign of stickiness, and "comes up." Chamois-leather rubbers give a very fine finish.

Wax polish is dull as compared with French polish, but more durable, and easily renewed if injured by heat or scratching.

French polishing requires much care and practice, as the success or failure of the process depends on the *manner* of applying the polish. The process is described very lucidly in "Marqueterie Staining," by L. V. Fitzgerald. Though a comparatively troublesome business, French polishing is well worth attention, as it gives a surface which can hardly be equalled, certainly not excelled, by any other process.

POKER WORK.

Poker work—or, to use the more grandiloquent term, Pyrography—is an art which deserves the serious attention of the artistic amateur, and may well be practised by people who, though not gifted with the capacity for originating designs, are interested in tasteful ornamentation. Its execution entails care rather than special talent.

The way of the pyrographer has been made smooth for him of late. The heated iron of former times is now a thing of the past, its place having been taken by a hollow platinum point kept at the proper heat by a blast of mingled gas and air sent through its interior. With the aid of this efficient instrument (to which the term poker cannot properly be applied) he may trace the most delicate lines, darken large areas, or burn away solid matter as desired.

Materials.—The material most commonly selected for poker-working is *white wood*—chestnut or sycamore—free from imperfections and rubbed very smooth. Wooden articles of many shapes and sizes, and designed for many different uses, are now sold in great numbers, either plain or with designs ready traced upon them.

Cardboard and *leather* are also suitable substances for treatment. *Velvet* can be "ironed" with a special point to give any pattern; and it is even possible to work on *glass*.

So far as wood and cardboard are concerned, poker work may be classified under two heads :—

(1.) Flat work; in which the lines are merely burned into a plane surface.

(2.) Relief burning; in which the background is sunk by means of carving and burning, so that the subject stands up boldly.

These two classes may be combined with one

another, and also with chip carving and marquetry staining. Flat designs are specially suited for artistic staining of the various parts, as the colour helps to prevent the "baldness" which is somewhat noticeable where large areas of white wood occur in a design.

Outfit.—Complete poker work outfits may be

Fig. 131.—Poker work outfit.

bought at prices ranging from a pound up to several pounds. The expensive item is the poker point, which, in order to withstand the high and constant temperature required, must be of platinum, the most expensive of all metals in common use. The price is governed by the amount of metal contained and the difficulty of manufacture.

The simplest outfit consists of :—

A *platinum point*, mounted on a tube sheathed in cork to form a convenient heat-insulated handle.

A *spirit lamp* to heat the point at the commencement of operations.

A *bottle* to hold benzoline. This is provided with a stopper having two separate passages from the bottom to the sides, so that air blown in may be well mixed with the benzoline gas before egress.

A *blowing ball* and air reservoir, similar to that used on a scent spray.

Rubber tubing to connect the benzoline reservoir with the blower and "poker."

The benzoline bottle and the spirit lamp may be combined, a tap and burner being added to the stopper of the last. In practice the separate and combined arrangements have each their own advantages.

For "relief" poker work a bellows of large capacity and worked by the foot is desirable. Many workers prefer the foot blower, as it leaves the left hand free for holding and moving the object being operated upon.

Platinum Points.—The greater the number of these that the worker possesses, the more accurately and effectively will he be able to carry out his designs. Any one who intends to do really high-class work should invest in at least three points of different shapes.

The "Edger" (Fig 132, A) is extremely useful

for making narrow, deep lines. The Knife Point (132, B) is invaluable for burning deeply into large areas, and should form part of the "relief" worker's equipment. The Shading Point (132, C) has the gas escape at the very tip—instead of at a distance from the point, as in other cases—and is held at some distance from the wood, which is scorched directly by the flame. Since the effect of the latter

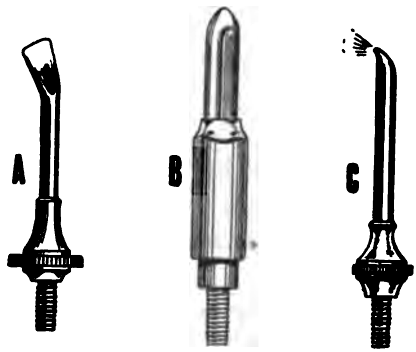

Fig. 132.—Three useful points: A, edge point; B, knife point; C, shading point.

is qualified by distance and the strength of the blast, a wide gradation of tone, such as is needed for portrait or landscape work, is obtainable. Other useful points are the Flat Sided and the Round Sharp. The spoon-shaped Modelling point greatly assists relief burning. If one point only can be afforded, the Flat should be chosen, as combining the qualities of most of the others named.

It is wise to buy the *best* quality points, as they last much longer than the cheaper brands.

Working.—The beginner should practise on valueless articles, to attain delicacy of touch and the knack of controlling the heat of the point by variation of the blast, before essaying work of a permanent character. Straight and curved lines should be repeated until the hand has got the right

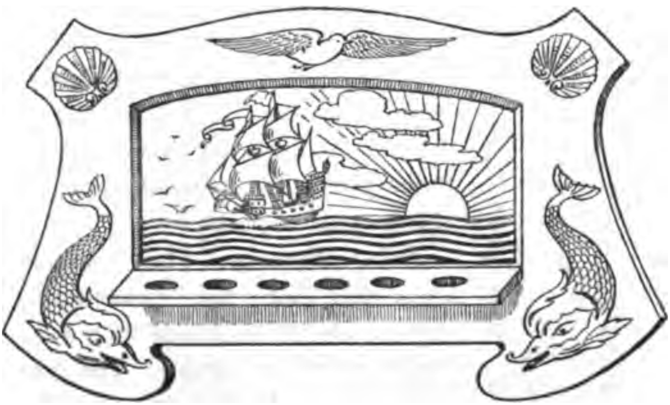

Fig 133.—A pipe rack ornamented with "flat" poker work.

"touch" for strong or light marking, and the point is drawn at that consistent speed which alone will obviate the spotty appearance of ill-executed work.

Then follows the burning of *backgrounds;* which is not so simple a matter as it sounds, since the whole of a background must be kept even in tone. The existence of a number of spots where the

Fig. 134.—Design for paper knife. Shaded portions stained: flowers red, leaves and stem green.

point has burnt in to a greater depth than elsewhere gives a very bad effect. The shading point is very valuable for toning down light patches.

As soon as reasonable proficiency has been attained, a simple design on a prepared article may be attempted. Don't be too ambitious at first, but restrict yourself to small objects, such as card boxes, pipe racks, etc. It will be time to launch out into big undertakings when you have mastered the rudimentary principles.

Relief Burning.—This requires more skill than "flat" poker work, as one has to deal here with solid shape as well as outline. The pattern having been burnt in, the background must be sunk by means of a carver's gouge and a Knife Point, the first being used for the rougher part of the work, the second for the finishing up. The charred wood is removed by a steel wire brush. Well-executed relief is extremely pleasing to the eye—gives, in fact, much the same effect

as carving, though accomplished more easily, as the hot point takes little notice of grain. (Fig. 135.)

Designs, Tools, etc.—Books of designs are published by Moeller and Condrup, 78 Fore Street, London, E.C., who also supply all tools and materials.

Book on Poker Work.—For full details of this

Fig. 135.—Example of relief burning work. This is the most effective branch of the art.

interesting work we would refer our readers to "Poker Work and Modern Relief Burning," by W. D. Thompson (L. Upcott Gill; 1s. net). It deals with working on leather, cardboard, velvet, and glass, and gives chapters on staining and French polishing.

Chapter XXV.

FRETWORK.

IN perhaps no other way can useful ornaments for the home be made so quickly as by fretwork. Twenty or thirty years ago the word "fretwork" was associated with fragile and dust-collecting ornaments, crudely cut from fantastic and badly printed designs. But within recent years the hobby of fretwork itself and the general attitude towards it have undergone a transformation: from a mere pastime fretwork has developed into an art craft.

An ordinary fret is one in which, the pattern having been traced or pasted down on the wood, the surrounding waste parts are cut away, leaving the design portion solid. Beautiful ornaments may be produced in this way alone; but with the more modern developments artistic effects are had by means of inlaying, overlaying, and underlaying; and, when metals and white or coloured xylonite are used in conjunction with wood, the result may be remarkably fine.

Tools : Saw-blades.—The best saws are made with the teeth fairly far apart, thus preventing the blade from getting locked in the wood. The saws are sharp, well tempered, and, as the backs are gently rounded, there is no burr to entice the blade away from the pattern line.

For ordinary frets Nos. 1, 2, and 3 are most generally used. It is the style of pattern rather than the thickness of material to be cut that determines the size of blade used, and the reason that coarser saws are employed for large decorative frets is that the pattern of the latter is bolder and without sharp angles or delicate points.

Hand-frames.—Fret-cutting may be done by hand or with a treadle-saw. In the first case a hand-frame (Fig. 136, *c*) is required. The one illustrated has a screw in the handle and also one on the upper arm, by means of which both clamps may be raised or lowered. This means that the saw-blade can be tightened to any tension. Cheaper frames are made without these screws, but the better ones are worth the slight extra outlay.

Frames are supplied in lengths of from 12 in. to 20 in. from saw to back of arm. A 12-in. or 14-in. frame is much more easily worked than an 18-in. or 20-in. one. The latter has the advantage of being able to take in a larger piece of work, but,

as it is apt to be unwieldy, a 14-in. or 16-in. size may be regarded as a useful average.

Cutting-table.—For hand-sawing, a cutting-table (Fig. 136, *f*) is essential. This is a plain beech board, about 8 in. by 5 in., having a V opening in front, and at the back holes and slots by means of which the board may be clamped to a dining-room or kitchen table. It is better that the worker should make his own board (say about 12 in. by 9 in., as Fig. 136, *g*), since those purchased are on the small side. Two iron cramps hold it in position.

Drills.—Bradawls should never be used for boring entrance holes in thin fretwood, and, whether for treadle or hand-sawing, a drill of the Archimedean type must be added to the outfit. Fig. 136, *d*, shows the common Archimedean drill, which bores at each downward stroke of the bobbin. In the case of Fig. 136, *e*, the drilling action is continuous, the balance weights keeping the point revolving while the bobbin is drawn upwards for the next stroke.

Other Tools, etc.—The ordinary household tools come in as useful for fretwork as for all other woodwork. An occasional requisite, however, is a shooting-board (Fig. 137, *b*) with a small iron plane. For tiny brass screws a pocket screw-driver is useful, but as a substitute the bradawl may be pressed into service. A pair of pliers

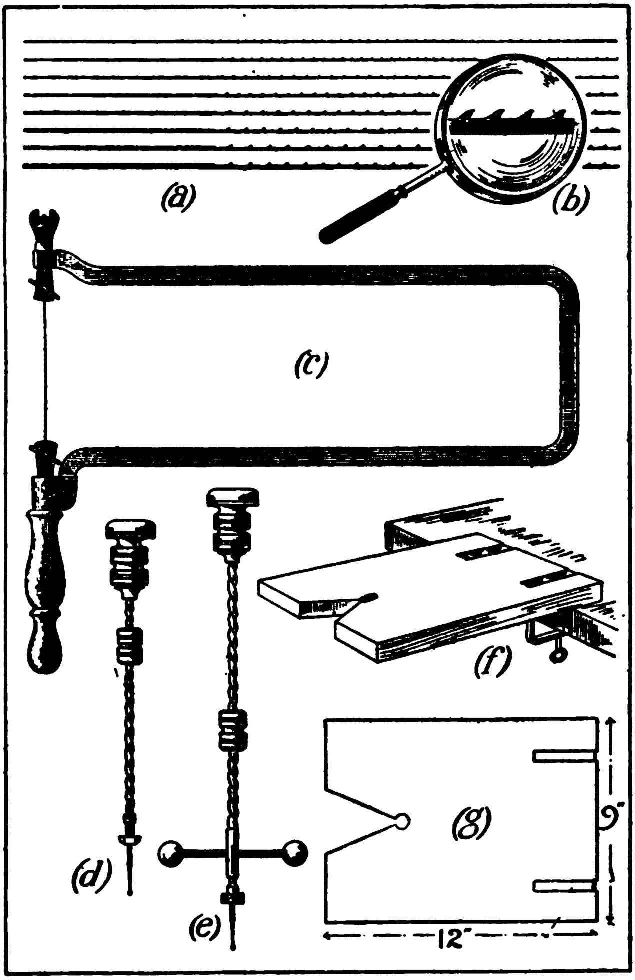

Fig. 136.—(*a*) Fretwork saw-blades. (*b*) Teeth of saw, magnified. (*c*) Hand fret-saw frame. (*d*) Archimedean drill. (*e*) Continuous-action drill. (*f, g*) Cutting table.

(preferably wire-cutting) is almost essential, and a cheap pair of pencil compasses and a straight-edge should be at hand. For regular use a sheet of black or blue carbon paper, some fine brass screws and wire nails, a tube of liquid glue, and a sheet or two of sand-paper and glass-paper may be regarded as necessities. One or two fine fretwork files, from 4 in. to 6 in. long, practically complete the tool list.

Treadle Fret-saws.—Although hand fret-cutting is widely practised, there can be no doubt that with a treadle fret-saw (Fig. 137, *a*) the pleasure and interest in this hobby is greatly increased. Treadle saws, if carefully used, will last a lifetime.

The great advantage of a treadle saw is that, as the stroke of the saw is operated by the feet, both hands are free to guide the wood. As this gives greater control, it ensures a better chance of accuracy. Then again, if the cutting-table be seen to be correctly at right angles to the saw-blade, the worker is free from the constant anxiety of maintaining a vertical stroke. It follows, too, that, as there is more power, cutting is quicker, and it is possible to saw heavier material; and, the stroke being more regular, finer and more delicate work can be executed.

Woods.—Of wood generally—of its structure and conversion—it is unnecessary to speak. Fretwood differs from timber used in carpentry and cabinet-

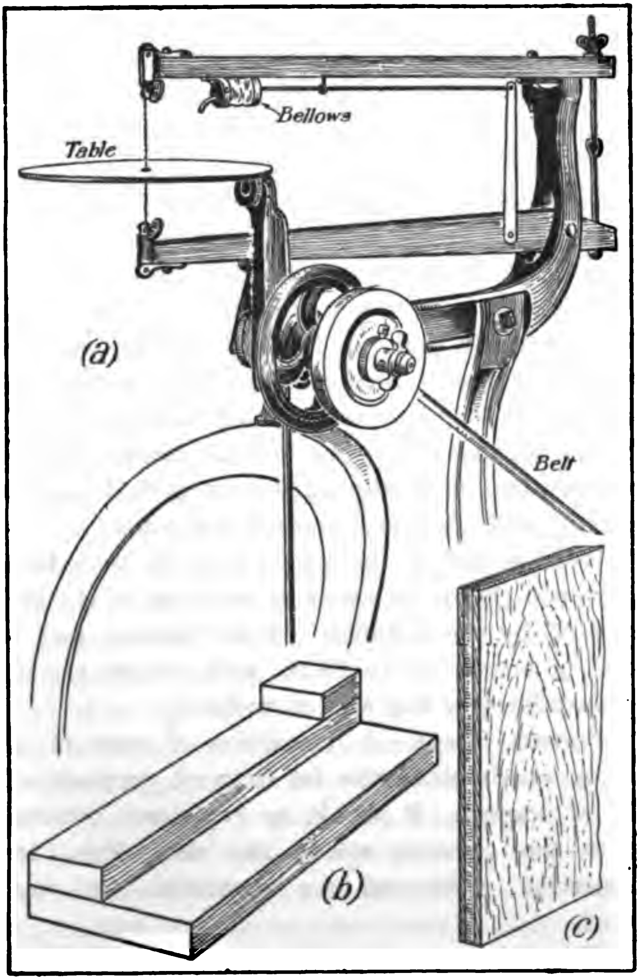

Fig. 137.—(*a*) Upper part of treadle fret-saw. (*b*) Shooting board. (*c*) Three-ply wood.

making only in that, as a rule, the finer kinds are employed, and these in thinner boards. The fret-worker may get what he requires in all thicknesses and with surfaces beautifully planed and sanded by special machinery.

Thicknesses.—The usual thicknesses are: $\frac{3}{16}$ in., $\frac{1}{4}$ in., and $\frac{3}{8}$ in. for ordinary frets; and from $\frac{1}{2}$ in. to $\frac{3}{4}$ in. for large, decorative fretwork. The $\frac{3}{16}$ in. thickness is most widely used for small ornaments, but for larger work cut from printed designs $\frac{1}{4}$ in. is also common. Boards of over $\frac{3}{8}$ in. in thickness are rarely found in the lists of fretwork dealers, chiefly because large work, such as doorway arches, screens, etc., is usually carried out in deal, bass, or canary, and afterwards stained or painted.

Wood is sold by the square foot, the price being governed (1) by the rarity or otherwise of the kind and (2) by the thickness. Some varieties may be had in boards up to 18 in. wide, others are not procurable over 6 or 8 in. in width.

Various Woods.—A description of some of the many woods obtainable for fretwork purposes will be of interest. It should be explained, however, that the common woods like deal, lime, and American whitewood are unsuitable for small work.

Holly is the purest white wood obtainable, and when glass-papered the finer boards have a resemblance to ivory. It is hard, very compact in grain,

and the sawdust has not a particularly agreeable smell.

Sycamore, close-grained, is not so hard as holly, but its silky grain makes it a favourite if the boards be untinged with yellow.

White Chestnut is softer, more open in grain, and with bolder figuring. As a substitute for holly it is the best procurable.

White Maple, although less purely white than the three woods just mentioned, is more generally useful. It has the advantage of being cheap, and its grain, though hard and close, is uniform and is not difficult to cut. Most boards have a nice faint figuring, and when glass-papered and lightly waxed the wood takes on a pleasant, dull gloss.

Canary or American Whitewood has too woolly a surface to make it suitable for use in thin boards. Of a pale yellow colour, with occasional dark streaks, it is useful for bold work.

Oak, when figured, is an excellent wood for backgrounds, especially when wax-polished either with or without a previous stain. For small ornaments it is rather strong in grain, but when the cutting is bold it may be used effectively. Oak is a wood that calls for great care in finish. It must be cut with a sharp saw and be very carefully cleaned up with glass-paper.

Satinwood is the finest, richest, and one of the most costly of yellow woods available for fretwork.

Of a delicate colour, it is hard, oily, and compact in grain, entailing some labour in the use of the saw. On account of its fragrance it is a favourite wood for dainty little ornaments.

Birch, of a light brown tint and even grain, is an excellent wood when a mid colour is wanted.

Elm, mild and rich, is also a useful wood; but, like birch, it is sometimes shunned because of its rather common name.

Satin Walnut has for many years held its own against all comers as the most popular of fretwoods. Known by the less attractive name of "gum," it is among the most common of American woods; but, on account of its cheapness, its soft grain, and its pleasant colour, it is more used in fretwork than any other wood. Of a soft brown colour, it is frequently marked with rich streaks, and the fact that it can be obtained in almost any width is another cause of its popularity. Its liability to warp is a fault that most amateurs are ready to overlook out of consideration for its qualities of cheapness and suitability.

Mahogany is not much used in fretwork, the reason being that mahogany looks its best only when French polished—a finish rarely bestowed on fretted ornaments.

Dark Walnut—sometimes called American and sometimes black walnut—is the favourite wood when something better and deeper in tone than

satin walnut is wanted. Although hard, it is not troublesome to cut, and when the boards are richly figured, as they often are, it is difficult to surpass. A touch of oil, followed by wax polishing, heightens the effect, and as a background for inlaying and overlaying it is widely used.

Rosewood, one of the most beautiful of all dark woods, is costly, gummy, and hard to cut; but its reddish-brown surface is finely veined and figured, and whether polished, oiled, or left plain it is always handsome.

Of stained woods there are two that must be mentioned :—

Silverwood is prepared from maple or sycamore, and is a beautiful silver-grey. As the stain permeates the grain, silverwood may be used for an ordinary fret. It has all the appearance of a natural wood.

Ebonia is much more useful than real ebony, as it is uniformly black. It is very costly, and for some purposes is unsurpassed in appearance, no other wood giving the same effect.

Three-ply Wood consists of three layers of thin wood glued together, the grain of the inner board lying at right angles to that of the two outer boards (Fig. 137, *c*). The advantage of this is that, when cutting a delicate fret, a fragile projection is less likely to snap off, as it is supported by the grain of the cross board. Much of the three-ply

wood at present supplied, however, is unsuitable for fretwork. The inner board is often different in colour from that of the two outer ones, thus marring the appearance of the cut edges. The gluing, again, does not always stand the friction of the saw, and the outer veneers peel off. Three-ply wood, to be suitable for fretwork, must be specially prepared for the purpose, and unless this can be guaranteed, the worker should use solid boards. Much of the three-ply at present provided is intended for cabinet-making purposes, and will not bear fretting.

Designs.—The secret of the popularity of fretwork is due largely to the extraordinary number and variety of designs available. American and continental patterns are little used now, as those published in this country far exceed them in quantity and style.

Patterns are printed by lithograph on thin paper, suitable for pasting to the wood. There are three qualities that a good design should have: (1) It ought to have some artistic merit; its grace depends upon the outline. A fret is not intended to be carved or etched, and if the outline itself does not convey its meaning, the design is at fault. (2) The article to be made should be useful—the useful here covering the really ornamental object fit for any home. (3) Designs should be practical. This means not only that the diagrams must be working drawings, but that the article, when carried out

according to directions, shall be reasonably strong. The fact that the wood is fretted tends to make it fragile, but a careful designer will so arrange his pattern that any delicate parts will be duly protected.

Transferring the Design.—There are two methods of transferring the pattern to the wood: (*a*) Tracing with carbon paper, and (*b*) pasting down. The wood must, of course, be smooth and clean before either is used. If only one surface of the fret is to be seen (as in the case of a photograph frame), the diagram is transferred to that surface of the wood, the reason being that the saw leaves a rougher edge on the under side. Diagrams are arranged so that the grain runs with the *length* of the article. This, of course, is not an unbreakable rule, but judgment should always be exercised as to the correct way the grain should lie.

Tracing.—If the worker can use his pencil with some skill he should trace his designs; if not, he should paste them down. Tracing is tedious work, but it preserves the pattern for future use, and saves the trouble of removing the paper when cutting is finished. A sheet of black or blue carbon paper is laid on the wood, and the design is placed above it and held by a few drawing-pins or tacks. The outline is then carefully traced with a hard and sharp pencil. All straight lines should be ruled, and circles or parts of circles be described

with compasses. An incidental advantage of tracing is that the carbon leaves an impression on the back of the design, and this provides a reversed diagram. When several similar pieces have to be cut from one diagram, and the worker is unable to saw them all simultaneously, tracing avoids the necessity of purchasing other copies of the design.

Pasting.—When a pattern is pasted down it cannot be used again, but this method has the great advantage of enabling the worker to cut direct from the original and not from a copy. Two things have to be avoided in pasting: (1) Moistening the wood sufficiently to cause it to warp, and (2) stretching the diagram when rubbing it flat. Use flour paste or starch (not gum or glue) for pasting, and when the pattern is down draw the brush over the back of the wood to counteract the effect of the moisture on the papered side. If a diagram be stretched or wrinkled in pasting (and paper always stretches slightly when wet), the risk is that the fixing joints will be thrown out of position. The best way to guard against this is to apply the paste to the wood. If the paper be rubbed down quickly, the risk is reduced to a minimum. When there has been no stretching, there is little chance of the wood warping. Neither drilling nor cutting should be proceeded with till the paper is *dry*.

Drilling.—All the interior openings of a fret have to be drilled to give entrance for the saw.

This is done with the Archimedean drill already mentioned (Fig. 136, *d* or *e*). The drill is held vertical, the left hand grasping the handle, while the bobbin is held in the right fingers. One thrust is often sufficient to pierce a thin board. The drill-point must not be pulled out, or it will break, but be withdrawn while running the bobbin up and down the stock as in boring. Work should be clamped to the bench or to a waste board when drilling. Holes are drilled near a point or angle which will form a convenient starting-place for the saw. After the wood is drilled it is well to sand-paper the back of the wood, as the drill leaves ragged edges which prevent the work from turning smoothly on the cutting-table.

Cutting.—The saw-blade is fixed in the hand-frame or treadle fret-saw clamps with the teeth facing downwards; the teeth also face outwards—that is, away from the arms. A saw cannot be used slack, but must be tightened to a suitable tension, and, as the strain on it is considerable, it must be securely held by the clamps. Several saws will be broken during a beginner's early attempts, but after some practice the death-rate is greatly reduced.

Hand-cutting.—When the hand-frame is used, the blade must be kept quite vertical. If it be allowed to lean to one side, the edges of the wood will be bevelled and irregular; if to tilt backwards

or forwards, the corners will be injured. Cutting, too, must be smooth, with a series of short, even strokes. The wood is cut on the downward stroke, but there should be no attempt to drag the blade through the board. The part being sawn is held above the V-shaped aperture of the cutting-table, the sides of this V giving support to the delicate fret. The wood is turned as required to meet the saw, but in hand-cutting most of the guiding is done by the saw itself.

Treadle-cutting.—The chief difference between hand-cutting and treadle-cutting is that, in the latter case, the position of the saw is stationary, except for the stroke. Thus the wood has to be fed up to the saw, all pressure and guiding being done by the fingers, which control the work. The importance of a vertical stroke is equally great, but, as this is determined by keeping the cutting-table at right angles to the saw, the matter of adjustment is simple. The easiest method is to test the saw against the edge of a thick piece (say 1 in.) of wood. In cutting thin or soft wood on a treadle-saw there is always a danger of attaining too high a speed. This should be avoided, as there is a limit of speed at which accurate cutting may be done.

Accuracy.—In fret-cutting, accuracy should always be the worker's principal aim. In this he is assisted by remembering that the finished object

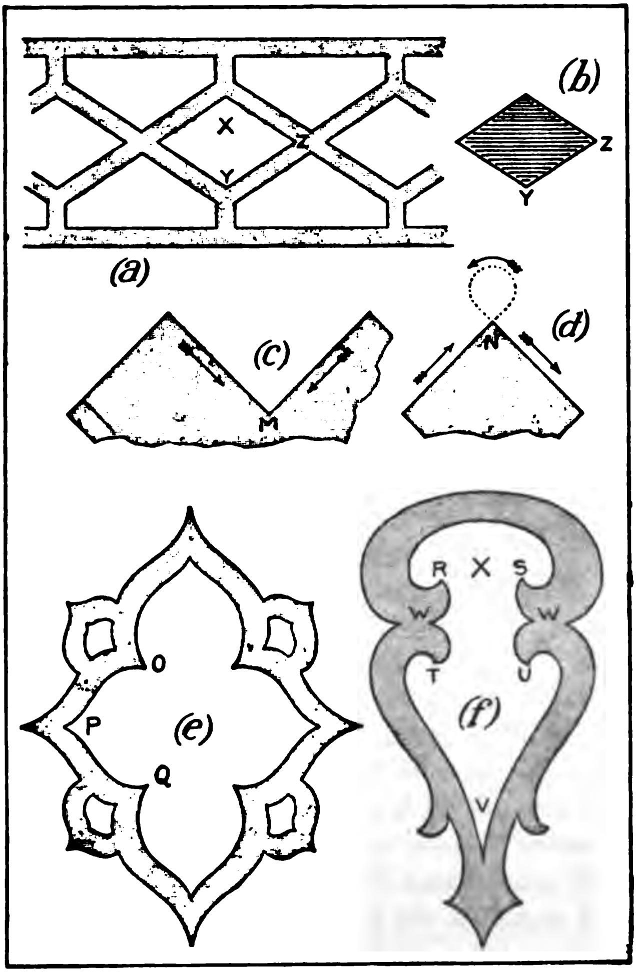

Fig. 138.—Hints on cutting fretwork.

is not the part cut away, but the part left in. The eye should thus be kept, not on the waste wood being sawn out, *but on the solid pattern that is to remain.* If, for example, we are cutting a fret like Fig. 138, *a*, the fact that the part lettered X may be a diamond form, like *b*, is unimportant; what concerns the cutter is that each line (Y Z) of the diamond is part of an intersecting band, and it is the band and not the diamond that has to be watched. If all the interior parts were cut out as independent ornaments there might be little unity in the finished fret.

Cutting Corners.—When angles like Fig. 138, *c*, have to be cut, sharpness is desirable, and the best way to secure this is by running the saw down one side to M, then withdrawing it and running it down the other side. The cuts meet and leave a sharp corner. When it is not possible to do this, the blade must not be turned abruptly, or it will break; it should be moved slowly up and down *without cutting* till it gradually eases itself in the waste and faces the new line. If this be done carefully the blade will leave a clean angle.

Cutting Points.—A projecting point is more easily taken than a corner, and is cut as Fig. 138, *d*. If N represent the point, the saw is run up from one side, but instead of turning at the point it is run right into the waste wood, as indicated by the dotted line. It thus strikes N from the other side

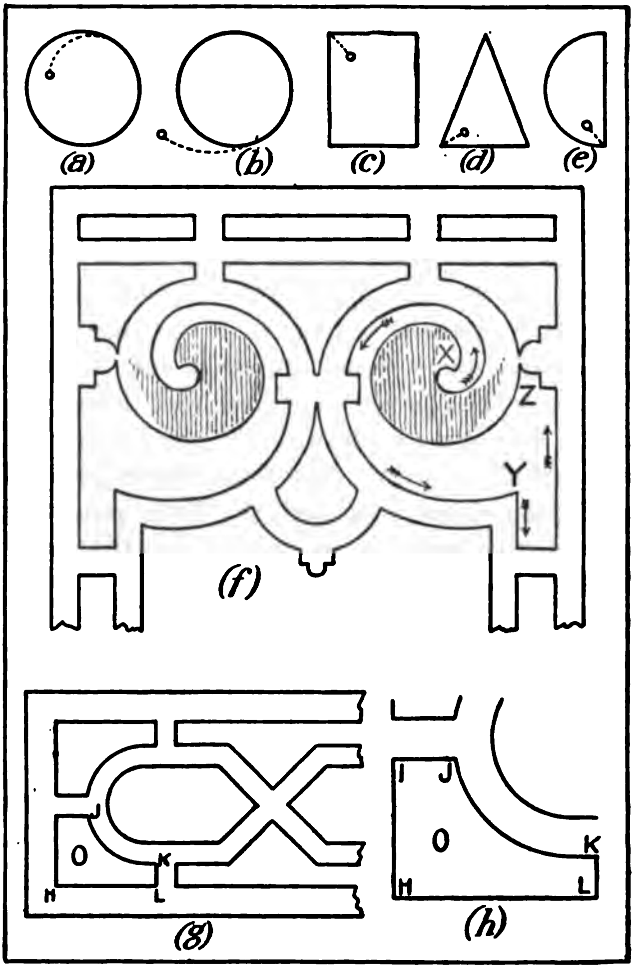

Fig. 139.—(*a*, *b*, *c*, *d*, *e*) Different forms; where to start. (*f*) A delicate neck. (*g*) Cutting openings at end of a long fret. (*h*) Enlarged detail of *g*.

and leaves a sharp angle. Figs. 138, *e*, and 138, *f*, further illustrate this method of cutting corners and points. At *e* the hole drilled may be in the centre of the fret, and the first cut run from O to P. The blade is withdrawn to the centre and run to Q and then on to P. All four corner forms may be done in this way, leaving sharp points everywhere. In the case of Fig. 138, *f*, a start can be made at X, and the saw run to R and then round to S. The waste wood will drop out, and the blade may then be run to T, and from there down to V. Here it is withdrawn to T, run across to U, and sent down to V. The lower waste piece of wood then drops out, and the little remaining sections may be taken by approaching the corner W, first from R and then from T, the opposite section being done in the same way. Of course, many fretworkers would cut openings like *e* and *f* (Fig. 138) without a pause, but if accuracy be wanted the method suggested is preferable.

Circles and Ovals.—When cutting these the saw approaches the circumference at a tangent. Thus, an interior circle or oval will be taken as Fig. 139, *a*, and an exterior one as Fig. 139, *b*. When beginning to cut a square, triangle, or any other form which has no projecting point from which to start, the saw may begin at a corner, as Fig. 139, *c*, *d*, and *e*.

Cutting Delicate Frets.—As the saw-hole in the

iron cutting-table of a treadle machine is so small, delicate frets are well supported; and if one gets broken in cutting, it will be due to pressing the work too heavily against the blade. In hand-cutting, the delicate part being sawn should be placed above the circular hole at the apex of the V opening of the table.

Fragile parts, however, are often in danger when a heavy piece of loose waste is left hanging to a delicate neck of wood. Fig. 139, *f*, illustrates this. The fret may be quite strong when finished, but the parts shown shaded may easily be broken when cutting. If the saw begins at X and goes in the direction of the arrows round to Y and Z, the shaded part has a big piece of waste hanging to it. The leverage of this will cause extra friction as the saw goes on from Z to X, and a jerk might break the narrow neck of wood which remains. The safe plan is to begin by cutting the part from Z to X; then go round by the arrows to Y and on to Z. In this way the fragile work is first separated from the heavy waste part. When large openings are being sawn, it is a good plan to release part of the waste (that is, cut it through) before the whole is circumscribed.

Breakages.—Should a breakage occur when cutting, it is well to repair it at once, otherwise the injured edges may get further damaged. If the broken piece be at once glued into its right posi-

tion, with little strips of paper pasted over both sides, it will hold. When the wood is afterwards sand-papered the mishap is not likely to be noticed.

Large Cutting.—At first it may appear to the worker that he cannot cut a piece larger than the "swing" of his saw—that is, the length from saw-blade to back of arms. It is, however, quite possible (though not always convenient) to cut work nearly twice this length. A treadle fret-saw has usually a swing of about 18 in., and we may suppose that Fig. 139, *g*, is the end of a fret 20 in. long. There will be no difficulty in cutting any of the openings except two or three at each end. Take, for instance, O (see Fig. 139, *h*). A start may be made at H, and the saw taken to I, J, K, and on to L. Here, if an attempt be made to turn the wood so that the blade faces H for its final lap, the far end of the wood will knock against the treadle-frame (or against the back arm of hand-frame in hand-cutting). To cut L H the saw has to be retraced to H, and the line taken the other way. To do an end opening like this the simplest plan is to begin at H and cut to L, then draw the blade back to H and proceed by way of I, J, and K to L. In large work the awkward openings may all be negotiated in this way. It ought to be said, however, that in large cutting the real difficulty is in conveniently handling a heavy board.

Importance of Ties.—Frets, like stencils, are held

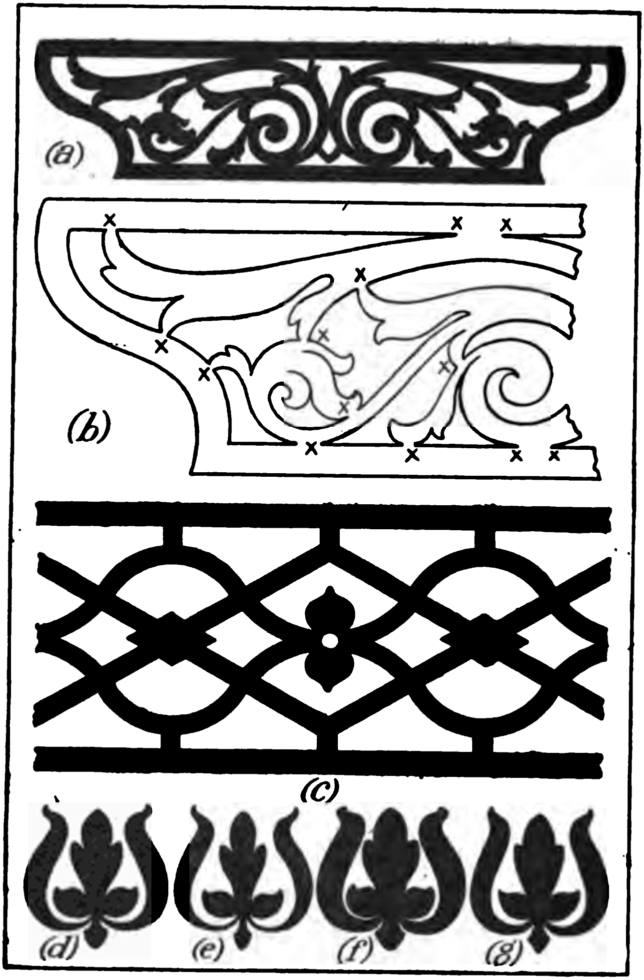

Fig. 140.—(*a*, *b*) Ties. (*c*) Intersections. (*d*) Leaf form. (*e*, *f*, *g*) Faulty representations of *d*.

together by "ties." But the difference between the two ornaments is that, while the *cut-out* part of a stencil represents the design, the fret pattern is the solid wood. Thus, while a stencil tie separates the finished ornament into many parts, the fretwork tie binds the whole ornament together. The importance of ties should always be borne in mind when cutting. On good designs they are never obtrusive, but they should be adequate for strength. At Fig. 140, *a*, is shown a small fret the ties of which are quite natural. At *b* is shown the enlarged detail of an end. When the tie corners lettered X are approached, there are three points to watch: (1) As the tie is there only for strength, the eye must carefully watch what is beyond; (2) the saw must not run too far into the corner, or the tie will be weakened; (3) the tie must not be left too thick or it will appear clumsy.

Intersecting.—Ties often take the form of intersecting lines, as Fig. 140, *c*. Geometrical forms are troublesome, not so much because the lines are specially difficult to follow, but because mistakes are more readily detected. In the case of Fig. 140, *c*, the ties (or intersections) are all part of the ornament, and accuracy and strength alike are secured by observing and following the continuity of line. Long, straight lines are usually broken by several ties, and when a tie corner is approached the eye must be kept on the line beyond.

Removing the Pattern.—If the pattern have been pasted to the wood, the paper adhering to the fret after all cutting is done has to be removed. An easy way is to damp it and then peel it off. But this method has two serious drawbacks: the moisture raises the grain, and also renders the wood liable to warp. The safest plan is simply to remove it with sand-paper. If the paste have not been very strong, many parts will peel off easily. When the diagrams have been transferred by means of carbon paper, any traces of the outline will be removed in the course of sand-papering.

Filing.—If cutting have been accurate, files should not be required for the purpose of correcting mistakes. Many expert cutters, indeed, never use a file. Some woods, however, are left with very ragged edges by the saw—that is, edges to which the fibres of grain hang—and these are sometimes more easily cleared away with a file than with glass-paper.

Sand-papering and Glass-papering.—Many well-cut and otherwise well-finished pieces of fretwork are spoiled through inadequate attention to sand-papering. Sand-paper and glass-paper produce clean edges and a beautifully smooth surface, and if this part of the work be neglected or hurried over, the article can never look well. There are three stages in sand-papering—general cleaning, clearing the edges, and smoothing.

Cleaning.—When a fret leaves the cutting-table it is slightly soiled and has numerous ragged edges. The upper surface is fairly smooth, but the teeth of the saw have dragged the grain down, and the back of the wood is rough. If the fret be well rubbed with a stiff brush, many of the ragged threads will come to the surface, and may be sand-papered off with the preliminary cleaning. The work should be clamped or otherwise secured to the bench, and the sand-paper, wrapped round a cork pad or held in a sand-papering block, rubbed over it. Coarse sand-paper is never required for fret-work, and if new pieces of medium grade are used, two sheets should be first rubbed together to get rid of any large grains. Sand-papering is done *with* the grain of the wood (not across), and when the work is small it is more convenient to lay the sheet flat on the bench and rub the wood over it.

Edges.—When the work has been well cleaned on both sides, the edges must have attention. The outline and every interior opening should be examined and stray threads of grain picked off. Where the saw has cut against the grain the edges will be fairly smooth, but where the blade has been with the grain the fibres will cling stubbornly. Most of these can be reached by folding a little strip of glass-paper round a thin piece of wood and using this as a file. On no account should the work be left until every trace of raggedness has been removed.

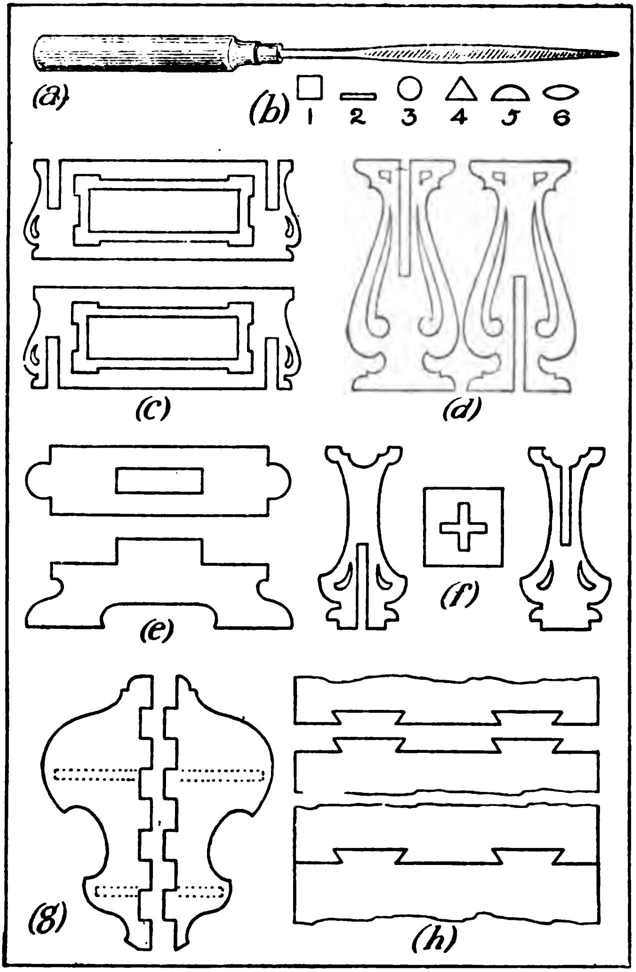

Fig. 141.—(*a*, *b*) Files. (*c*, *d*) Halved joints. (*e*, *f*) Tenon joints. (*g*) Lap joint. (*h*) Dovetail joint.

Smoothing.—For finishing the fret, fine glass-paper is taken and both surfaces well rubbed, with the grain as before. If the wood be white, paper which has previously been used on dark wood should not be used. For the final rubbing a piece of well-worn paper is useful. Some woods, such as white maple, take on a natural polish with the final smoothing, and a practice occasionally adopted is to rub a little beeswax over the worn glass-paper in order to heighten the dull gloss.

Nails, Screws, and Pins.—*Nails* are never used for fixing fretwork except in cases where the nail is hidden. Incidentally, however, brass or iron wire nails, from ¼ in. to ¾ in. long, are of service. When used, it is advisable to drive them in slightly aslant (Fig. 142, *a*), in order that two may act like a wedge.

Screws for fretwork are of the finest gauge, brass ones being preferable. They are obtainable in sizes from $\frac{3}{16}$ in. upwards, but these tiny ones, unless driven with extreme care and accuracy, afford very little hold. The more useful sizes are ⅜ in., ½ in., and ¾ in. Holes must always be properly drilled for screws, and it should be seen that the hole in the upper piece of wood is sufficient to take the shank easily, and that it is countersunk for a flat-headed screw. Unless these precautions are taken thin wood will split. For hidden fixtures, flat-headed screws (Fig. 142, *b*) may be taken;

but if the screw is to be seen, a round-headed brass one (*c*) should always be used. A fine-bladed screw-driver is required for these small screws (a bradawl kept for the purpose is useful), and when a very hard wood, such as ebonia or rosewood, is in hand, some care must be exercised not to let the screw break.

Pin Points (or needle points) are used a good deal in fine work, especially in cases where a glued joint is to be strengthened. A household pin is cut off (with the wire-cutting pliers) $\frac{1}{4}$ in. or more from the end, and the point used like an ordinary nail. The great advantage of these pin points is that the blunt end can be pressed (with the pliers) into one part of the joint, and the other part then be pressed down on the point. When this is done no trace of the pin is visible.

Incidental Fixtures.—Hinges used in fretwork are small brass butts, and may be had from $\frac{1}{8}$ in. upwards. Ornamental hinges for boxes, etc., may also be obtained from dealers in fretwork materials. Butt hinges are fixed as in cabinet work, the chief difference being that the hinge is smaller and the wood thinner. Indeed, the thinness of the wood makes the fixing of fretwork hinges troublesome. In some cases the screw has to be driven right through the wood and its point afterwards filed off. At Fig. 142, *d*, is shown an easy (but not very workmanlike) method of fixing a hinge for a photo-

graph frame strut. A better way is indicated at *e*, where the wood in both cases is rebated to take the flaps. At *f* is shown how doors (or the two sections of a folding door) may be hinged, the flaps being rebated to the face of the wood. At *g*, again, the hinge is shown with the screws passing into the edges.

When fretwork boxes are joined at the corners by halved joints, the lid is sometimes designed to lift off. Frequently, however, it is planned as section Fig. 142, *h*, the outer border (X) being fixed to the sides, while the centre (Y) is hinged. A flat ornamental hinge is the easiest to fix here; if a butt be used, it is hinged as at Z.

Framing Photographs.—The favourite method of framing a photograph is as Fig. 143, where *a* represents the front view, *b* the back, and *c* an enlarged section. Frames are usually provided with overlay borders, the inner edges of these overlapping the picture opening in the back by about $\frac{1}{8}$ in. at each side. In this way a rebate for print, glass, and back board is formed. The back board (a piece of $\frac{1}{16}$- or $\frac{1}{8}$-in. wood) is shown at *b*, held by four small metal photograph clips. The section *c* clearly explains the fitting.

When there is no overlay, a back framing has to be fixed behind the frame, as Fig. 143, *d*. This consists of four narrow strips, mitred at the corners and glued on. To provide a rebate, they are set

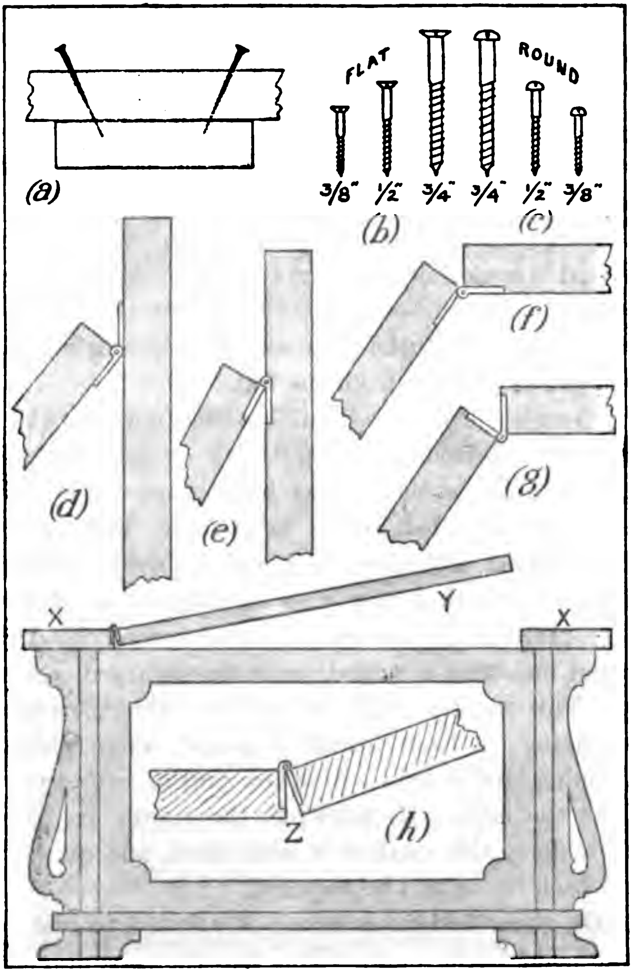

Fig. 142.—(*a*) Nails driven slantwise. (*b*) Flat-headed screws. (*c*) Round-headed screws. (*d–g*) Methods of hinging. (*h*) Hinging box lid. Enlarged section at Z.

back a little from the edge of the frame opening. The glass and back board are then fitted in the way just described. As, however, the print is in this case rather deeply recessed, it is a good plan to chamfer the front edges of the frame opening.

As an alternative to method *d*, an over-all back board is sometimes fixed as Fig. 143, *e*, the sectional sketch being self-explanatory. If the top framing strip be omitted, the glass and photograph may be slipped in and out from the top.

Framing Mirrors.—Small bevelled mirrors, which are often introduced in fretwork designs, may be fitted in the same way as photographs. As they are not intended to be removable, however, a back board with clips need not be used. Mirrors invariably look better with an overlay, as section Fig. 143, *f*. Sometimes a little turned bead or pearl moulding is added, as in the enlarged section *g*. This section *g* also shows an ordinary method of fixing: a back board is added, as in picture framing, and is held with a few pins or nails passed into the edge. If, however, the mirror be fitted to a door, this method is unfinished, and an over-all back board will be required.

On some designs a mirror is allowed to rest on the solid background. This has the advantage of making it stand well forward, but two overlays (as Fig. 143, *h*) are then required to hold it. The first overlay (with an inner opening to fit the

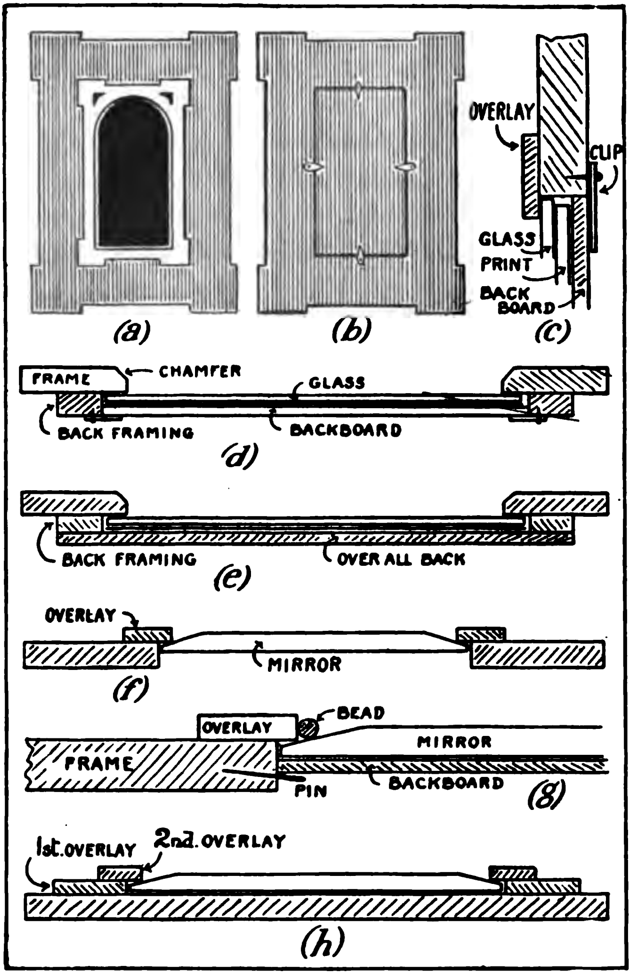

Fig. 143.—(*a–e*) Methods of framing photographs. (*f–h*) Framing mirrors.

mirror) is glued to the background as shown. The second overlay, lighter and usually a little thinner, overlaps this first one, to which it is glued after the mirror is placed in position.

When a very large mirror is used for an article, such as an overmantel, a well-made frame is, of course, required. The frame will assist in the general fitting.

Polishing and Staining.—Many fretwoods look so well in their native state that it is customary to leave small articles unpolished, but when the worker understands the different methods of finish, he can obtain good effects by one or other of these processes. Whatever is done, the rule may be laid down that varnish must never be used, unless, perhaps, in bold fretted arches or screens cut in thick wood and afterwards stained. Varnish is an unsuitable finish for small work, giving the article a heavy and sticky appearance.

Staining (except in the case of very large work) is not often required, for the simple reason that the woods used are specially chosen because of their colour and grain, and do not need alteration. Prepared water stains to represent all kinds of woods, however, are now obtainable, and for backgrounds these are sometimes useful. It is always better to give several coats of diluted stain rather than one heavy coat, a more even and natural surface being thus secured. When dry the wood

must be well glass-papered before any polishing is attempted. Stained wood always requires a final finishing—waxing for oak, and oil polishing or French polishing in the case of other woods. An ebony stain should be followed by wax polishing.

Oil Polishing is a process that yields beautiful results, but as these depend almost entirely on the amount of friction applied, this finish is accompanied by some danger to delicate frets. It is, moreover, the most tedious of all processes. An "oiled" finish is frequently seen on frets, but as the oil has been applied like a varnish, and has not been properly rubbed, the result is a greasy, sticky surface which collects every grain of dust. The secret of oiling is rubbing, and unless there be time and patience for this, oiling should not be attempted. Raw or boiled linseed oil is used. The customary plan is to let the oil simmer over a fire (not boil) for ten or fifteen minutes, then remove it and add a little turpentine, say, an eighth part. The turpentine helps the oil to dry more quickly. A piece of felt or several thicknesses of flannel are wrapped round a wood block and the oil applied by means of this. As the grain absorbs the oil, many applications are necessary, and the rubbing may be continued daily for weeks. Short of breaking the fret, no amount of rubbing can do harm. An oil-polished surface does not blister nor crack, nor is it stained by water.

Wax Polishing is one of the most satisfactory as well as the easiest of methods for the amateur, and on woods like oak, white maple, dark walnut, ebonia, and others, it produces a rich, dull gloss. To prepare the polish, some beeswax is cut into fine shreds and dissolved in turpentine, a suitable consistency being that of soft butter. On account of its inflammable character, the wax should not be heated, but left overnight to dissolve. The turpentine plays no part in the actual polishing, but is used as the best medium for dissolving the wax. It quickly evaporates. The polish is applied with a brush or rag, care being taken not to clog up corners. The final rubbing—and there must be plenty of it—is done with a fine flannel (without fluff) or a chamois leather. A waxed surface is spoiled by water, but a fresh application of the wax will repair the injury.

Fuming.—On oak a beautifully rich dark stain is obtained by subjecting the wood to the fumes of ammonia. A wood or tin case is made air-tight by pasting paper over all corners, etc. A saucer with liquid ammonia is placed in the case, and above this the wood article is suitably suspended, so that the fumes get well around it. The wood will gradually darken, and when the desired shade is reached it is removed and wax polished. Oak may be stained, though less effectively, by several coats of diluted ammonia applied with a brush.

Chapter XXVI.

BOOKBINDING.

Bookbinding without Tools—Repairing Old Books—Mounting Maps.

IN every home there are periodicals and books issued in parts which one may wish to keep, though not considering them worth the expense entailed by having them bound. It is possible, however, to do the binding at home, at very small cost, and so convert a number of untidy units into quite respectable-looking volumes.

Every book is built up in sections, as will be understood after examination of an old volume which has become dilapidated. (Indeed, the would-be bookbinder, in order to follow the ensuing description more easily, is advised to dismember for himself some book which can well be spared.)

The first operation is to get all the sections together, after robbing them of advertisements and all other extraneous matter. In the case of periodicals, each number either is a single section or is made up of several sections fastened together by

wire staples, which must be drawn out with pliers. Each section consists of a number of pages folded one inside the other.

When all the sections have been prepared, they should be arranged in the proper order, with the title-page, etc., at the bottom. The tops and bottom edges of the pages should be levelled off, also the backs ; after which the whole pile is subjected to the greatest pressure obtainable. One may not have a press, but weights of some sort can be found wherewith to squeeze the embryo book as flat as possible.

Get two pieces of fairly wide tape and soak them in flour paste to make them stiff, and lay them out to dry. While the sections are still under pressure, rule down the back six lines (in pencil) as shown in Fig. 144, *b*, taking care that the pencil marks every section—that there are six marks on each. The spaces between lines 2 and 3, and 4 and 5, should be equal to the width of the tapes, for a reason which will soon be apparent.

Instead of marking the back with pencil as already described, one may make a gauge out of a strip of tin or other thin metal. To do this, bend the strip longitudinally to a V shape and make six small holes along the apex of the V, spaced just as you would space the pencil lines in the other method. (Fig. 145.)

To use this gauge, open each section and lay it

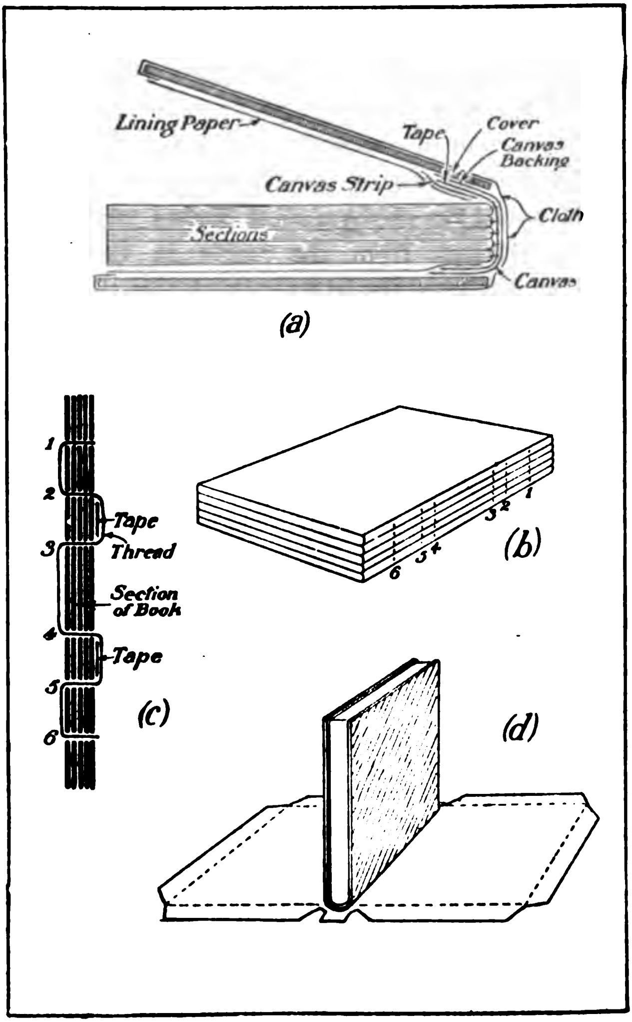

Fig. 144.—Bookbinding operations.

back downwards upon a board. Place the gauge upon it and pass a fine awl or large needle through each of the holes into the paper. The sewing, in which you will of course use the holes thus made, will by this means be perfectly regular, and you will be saved the annoyance of finding your needle coming through from the inside in the wrong place, as it is very apt to do.

Now turn the whole pile over so that a new pile may be built up in the same order, when the sec-

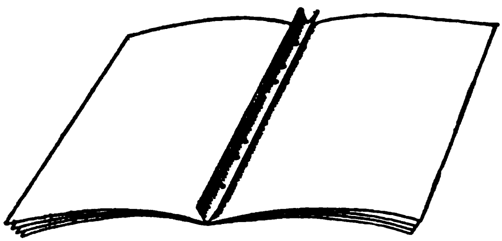

Fig. 145.—Gauge for making sewing-holes in book sections.

tions are taken one at a time and sewn together in series. Remove the top section, which we will call A, from the inverted pile, and, turning it over, make it the bottom one of the new pile.

Sewing.—Taking a needleful of stout thread, pass the needle with the right hand through the first section at mark 1, seize the point as it comes through the inside fold (with the left), and pull the thread right through. Pass it back from left to right at point 2; return it through point 3, after laying it

over one of the tapes. In the same way pass the needle out at 4 and back at 5, enclosing the second tape. If a section were now opened out flat and looked at edgewise, the tapes being viewed endwise, the thread is seen to pass to and fro as in Fig 144, *c*. It would not, of course, be left as loose as shown —for clearness only.

The thread having been brought out at point 6, section B is laid on A, and the process of stitching repeated, but in the opposite direction, entering first at 6 and finishing at 1. The loose end of the thread is then secured by being tied tightly to the thread as it emerges from point 1.

Section C is treated similarly to A, excepting that the thread, after emerging at 6, and before entering section D, is passed through the loop between sections A and B. The process is repeated until all the sections have been taped.

After each section is sewn pull the thread tight, firmly but gently. Make certain that the needle has not passed through the tapes but round them, so that the tapes may be pulled tight and the sections drawn close together. When the first piece of thread is exhausted, tie another piece to it, so that the thread shall run continuously through the book; and when the last section is sewn, finish off by tying the thread to the loop between the preceding pair of sections.

We may now review what has been done. Each

section is attached by two loops to two tapes, which serve as links common to all sections. At points 1 and 6 the sections are tied together by the thread passing straight from one section to another, or by the back-loop through the thread joining the previous two sections.

Gluing.—Again subject the pile to pressure, pulling the tapes as tight as possible, after which the back is given a good serving of glue, laid on thick and worked under the tapes. While the glue is hot, lay over the back a strip of canvas lengthwise and two inches wider than the back, the spare at the edges being left unglued. Let the glue set hard.

Lay the book on the table, and, holding it down with the left hand, tap up and down the back with a piece of wood, to round it. Do the upper half first, then turn the book over and do the other half, and repeat the process until the back has a good shape. The front edges of the book will be uneven, but this is unavoidable, as it is difficult to get them level without cutting in a special machine.

Covering.—The two pieces of cardboard which form the covers are fastened on by gluing to them the projecting edges of the tapes and the free edges of the back canvas. The joint is made doubly secure by gluing two narrow strips of canvas lengthwise over tape ends and back canvas (Fig. 144, *a*).

The boards and back are covered by a single piece of book "cloth," cut large enough to lap over the three free edges of each board (Fig. 144, *d*) and the ends of the piece of brown paper stuck to the inside of the part which covers the back. When the cloth is dry, line the inside of the covers with stiff, smooth paper.

If the cloth be of a fairly light colour, the name of the volume may be written on the back in neatly printed letters; unless it be preferred to inscribe the title on a glued-on label.

Note.—If the book be a large one, three tapes may be used with advantage; but two will suffice for books of ordinary size.

REPAIRING AN OLD BOOK.

When a well-used book shows signs of coming to pieces, the best thing to do is not to tinker with it, but to rebind it entirely. We will suppose, to commence with, that the book in hand still has a good serviceable cover, but that the pages are getting loose. Turn the covers right back, and with a sharp knife slit right down through the cloth or canvas which holds the cover to the inside, also through the tapes or strings by which the sections of the book are bound together. Thus the cover will be entirely detached from the book, and can be laid aside for the moment.

Next separate the sections one from another. It

is not always easy to see which pages constitute the ends of a section; but in order to facilitate the binding, the printers put on the first page of each section a letter or figure, which is termed the "signature," and by looking for this one can avoid making any mistake. The signature is generally at the bottom of the page, and a little searching will find, probably at either eight or sixteen pages from the commencement, a letter B. The title-page, list of contents, etc., often constitute the first section, so that section B often begins with the first chapter. In like manner signature C will be found, generally sixteen pages farther on, and so on throughout the book.

All the pages up to, but *not including*, that marked B form the first section. From letter B to the page *before* C is the second section; and so on.

Gently and carefully pull each section from the rest of the book, severing with a sharp knife the thread with which it is sewn and the canvas pasted at the back. Then open the section at the middle and pull the threads out. Also scrape the glue, etc., from off the back.

If you come across any loose leaves they will be in pairs, for every leaf has a fellow leaf in the same section, and they hold each other in. Therefore if one be loose, so will the other. Take them both out and paste a strip of paper to the two so

as to join them firmly together again. Then put them back into the section again as they used to be.

Thus go through all the sections until the whole book has been done. Then set to work and bind them all up again after the manner already described.

That done, the old cover can be put on again by gluing the tapes and the canvas backing to them in the usual way. It may be well, however, to strengthen the back of the cover by gluing some brown paper to the inside.

If the covers be torn in any way, do not attempt to glue or cement a patch *over* the tear. Such a job is never satisfactory, for the reason that the edges and corners of the patch will come up. The covers, of course, are formed of leather or cloth pasted on to cardboard. With a paper-knife loosen the leather or cloth from the board where the tear is, and carefully glue a piece of similar material *under* both the edges thus raised. Then glue the under side of the raised edges and press them down upon the patch. The patch is thus underneath the old work—an arrangement which gives much better results than the patch on the top does.

MOUNTING MAPS.

A map attached by one corner to a cover of book form must be spread right out for consulta-

tion, and consequently is a rather unhandy article. If the paper be not backed, the map is sure to tear away from the cover sooner or later—generally sooner.

The best thing to do with such a map is, first of all, to loosen it from its cover by damping the stuck portion, and covering it with a piece of saturated white blotting-paper, with a piece of glass or other waterproof material on top. The adhesive will soon dissolve and allow the separation to be made without any difficulty.

The cover is then cut in half and stuck to the edges of one row of sections by hinges on both sides of the map (Fig. 146, *a*). The map can be folded then in several ways—rows A and C in front of row B, or behind row B; and either A or C may be on top of the other, or A may be behind and C in front, or *vice versa*, provided that neither A nor C is wider than B. In any case two-thirds of a three-row map can be seen by merely opening it concertina fashion, or by turning the folds over like the leaves of a book. Altogether the change will be found a great improvement.

Mounting Maps on Muslin.—A map may be backed either (1) as a whole, or (2) in sections spaced a fraction of an inch apart, so that there is no paper at the natural folds.

A good material for backing is book muslin, costing a few pence a yard run in 40-in. width. As

adhesive, one may use gloy, or paste made with flour, cornflour, or arrowroot in the ordinary way. A supply of paper, waterproofed by warming it

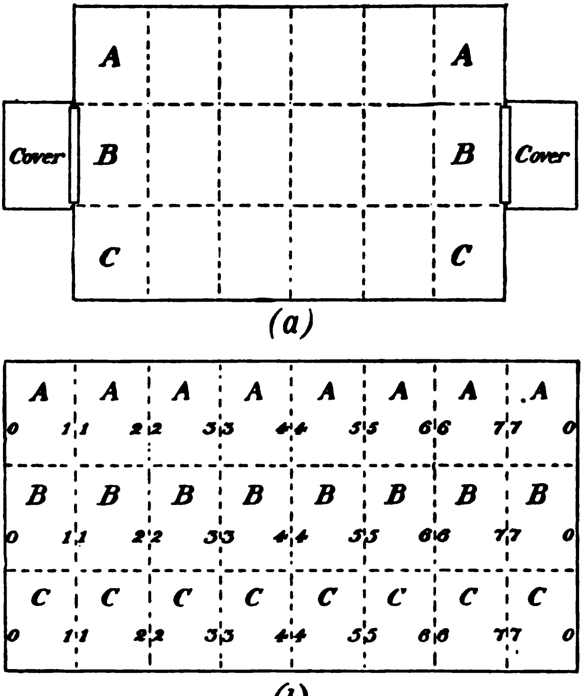

Fig. 146.—Mounting a map on muslin.

and rubbing it with paraffin wax, will be found useful; and it will expedite matters if a frame rather larger inside than the map be made by nailing some laths together.

Mounting a Map as a Whole.—Stretch a piece of muslin over the frame, securing it with drawing-pins. Damp the muslin to make it contract and become tight and flat.

The map is now laid face downwards on the table on an old newspaper, and well damped all over with an old sponge to make it expand. The adhesive is then applied with a brush, which must be worked outwards only across the edge to prevent adhesive getting on the face. Lift the map, taking care not to touch the edges, and lay it as flat as possible on a clean piece of paper. The frame is now lowered on to the map, and the muslin pressed everywhere into contact with the paper. Wipe off gently all surplus paste, lay the oiled paper on the muslin, and weight it with suitable flat objects, which should be in readiness. When the map has been under pressure for half an hour, the covering should be removed and the frame set on edge, so that air may reach the back of the muslin.

When the map is dry, cut away the surplus muslin, leaving half an inch all round to be folded over and stuck to the face to strengthen the map at the edges. Folding is done along the original creases, a hot iron being used to get neat folds. Place the folded map under pressure for a few hours.

Mounting a Map in Sections.—The map is soaked away from its cover, if it have one, and turned

back upwards for the sections to be lettered for rows and numbered for files (Fig. 146, *b*). Mount the muslin on the frame, and lay it in contact with a piece of oiled paper. A separate piece of paper should be provided for pasting each section on, so that paste may not be transferred to the face of a following piece.

Separate the map at the original folds, which should first be flattened down with a straight-edge to part more easily. Damp the muslin and all sections of the map. Beginning with A1, paste the back well and lay it in place, and press it down hard against the muslin, working from the centre outwards. Finish off a row or file before beginning another. The spacing should be ⅛ in. to allow adjustment for any irregularities in shape. The sections are weighted as soon as possible after placing, and left under pressure for some time after the sticking on is finished. The frame may then be stood on edge to allow the paste to dry thoroughly. Unpin the muslin from the frame and trim it, leaving a margin for pasting over the edge. When the whole is dry, fold the map up, iron it, and put it under pressure. The original cover may then be cut in two and stuck to the back of two end sections, which will most conveniently be outside when the map is closed.

Chapter XXVII.

USEFUL ODDS AND ENDS.

Cycle Stands and Slings—A Patch Clip—A Cycle Box—Jacketing a Cistern—A Trimming Knife—A String Cutter—A Sugar Scoop —Uses for old Photographic Plates—Home-made Files—Cheap Developing Dishes—Whipping a Rope End.

CYCLE STANDS AND SLINGS.

FIG. 147, *a* and *b*, is a stand for three cycles. It consists of six trestles similar to that shown in the end view (Fig. 147, *e*), strung together in pairs on three broom or other suitable sticks. A tie, T, about halfway up, prevents them spreading.

The materials required are: 45 ft. of 2-in. by 1-in. batten for the legs; 14 ft. of 2-in. by 1-in. batten for the ties; and three round sticks about 4 ft. 6 in. long.

The trestles are 3 ft. high vertically, measured from the centre of the top stick; and 2 ft. 8 in. wide outside the legs. The last are 3 ft. 6 in. long. They may overlap at the apex as shown in Fig. 147, *a* (this gives a longer bearing for the stick), or be "halved" together. In the first case the ties will need blocking out about an inch at one end

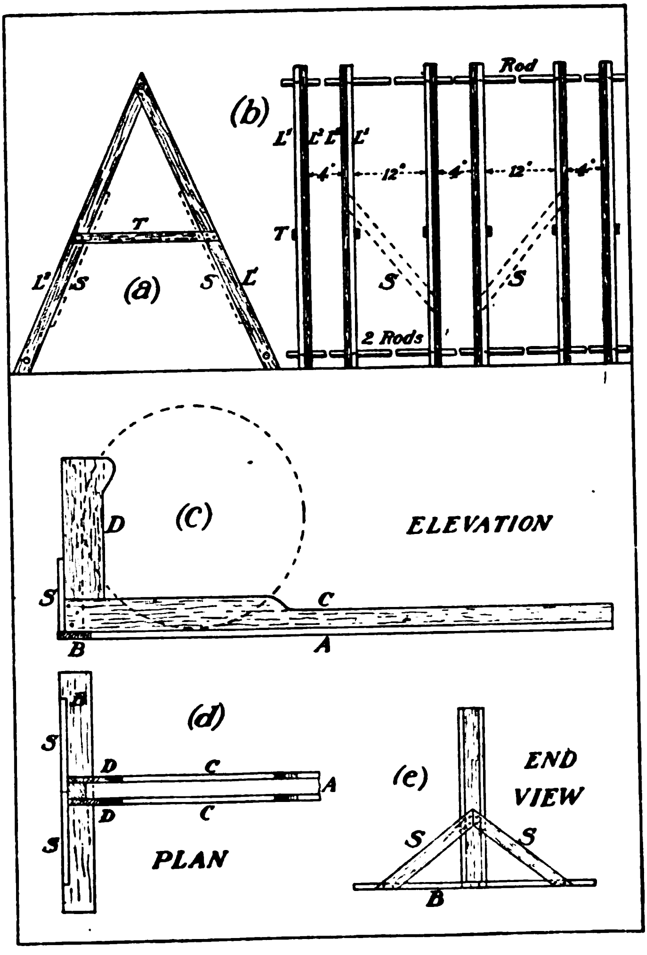

Fig. 147.—Cycle stands.

to run due fore-and-aft. It should be noted in Fig. 147, *b*, that the unshaded legs, L^1, which are on the side from which the machine is entered, are outside the shaded legs, L^2, so as to give plenty of room (about 6 in.) for the spindle of the front wheel.

The trestles should be made from a common template, chalked on the floor; and the stick holes be bored with a centre-bit as squarely as the skill of the workman permits, since it is obvious that if they are out of square there will have to be a good deal of easing to get the sticks through.

When the sticks are in position, and the trestles accurately spaced, screws should be put through the trestles into the sticks, or wedge-shaped nails be driven through the sticks just outside the trestles. These holes should be bored, after careful measurement—allowing for the fact that L^1 L^1 are at the base further apart than L^2 L^2—before the parts are assembled.

The two struts, S S, indicated by dotted lines, may be added on both sides to give the stand lateral rigidity, if it seem to be at all wobbly.

If the stand be intended for outdoor use, all parts of the trestles should be painted before they are put together.

As the cycle bays are 20 in. apart, centre to centre, cycles with handle-bars of ordinary width should not interfere with one another.

Fig. 147, *c*, *d*, *e*, are respectively side elevation, part plan, and end elevation of a stand for a single cycle. The base, A, is a 4-in. by 1-in. board about 5 ft. 6 in. long. At one end a 2 ft. 6 in. piece of similar board is "halved" across it, and at the point of crossing is stub-tenoned in a 2 ft. piece of 2-in. by 2-in. wood. To this are nailed two 4-in. by 1-in. side pieces, C, reduced to 2 in. depth aft of the front wheel, to form a wheel trough 2 in. wide; and two verticals, D D, shaped as shown out of a 6-in. board. The upright is stayed laterally by two struts, S S, nailed to the back and let flush into the rear edge of B. If D D be connected with C C inside by small plates, the fore-and-aft rigidity of the upright will be considerably increased.

A support to hold a cycle firmly against a wall is made by screwing a cross-garnet hinge to the wall and bending the end to form a hook at such a distance from the pivot that it will pass over the top bar of the frame when the saddle and handle-bar touch the wall (Fig. 148).

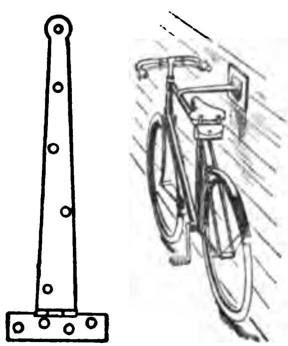

Fig. 148.—A simple cycle support made out of a "cross-garnet" hinge.

The simple apparatus shown in Fig. 149, *a* and *b*, is for slinging a man's cycle at a convenient

height for cleaning, overhauling, etc. The horizontal arms of the brackets, as measured from the hinge to the centre of the notches, N N, should be

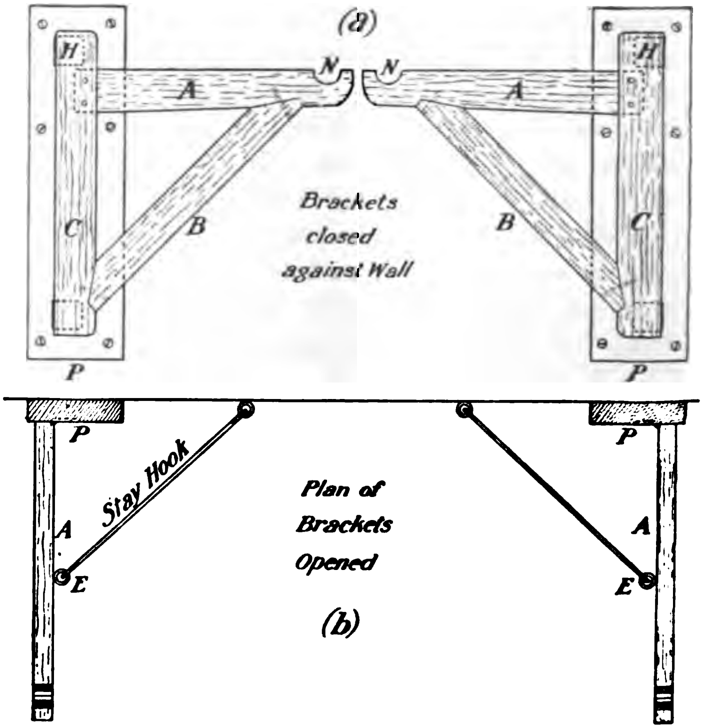

Fig. 149.—A cycle suspender.

rather longer than half the width of the handle-bars, so that the machine may clear the wall; and the distance between the brackets be suffi-

cient to allow them to be closed against the wall without overlapping.

The braces, B B, are notched into A A and C C as shown. A A are tenoned into C C, or, if this be beyond the constructor's capacity, "halved" on. The wall plates, P P, are secured by screws, for which plugs may have to be driven into the wall.

The hinges, H H, are sunk into C C and P P, so that the brackets cannot open beyond the "square" position relatively to the wall. To prevent the brackets moving inwards while cleaning is in progress, they should be furnished with long stay hooks (see Fig. 149, *b*), engaging with screw eyes, E E, in the brackets.

The cycle is suspended by the top tube running from the head to the saddle-pin lug. If the arms be too far apart to get inside the frame when perpendicular to the wall, E E should be placed rather nearer the ends of the arms. There might be several sets of eyes to suit the suspender for cycles of different lengths. The notches, N N, should be large enough to permit a little obliquity of the brackets to the cycle tube, and be lined with cloth, leather, or other non-scratching material.

The bracket arms should be at least five feet above the ground to minimize stooping.

A fixed suspender for outdoor use is made in a very few minutes by nailing two pieces firmly to

either side of a tree trunk (Fig. 150, *a*) or large post.

Another form of sling is shown in Fig. 150, *b*. For this one needs a horizontal branch, six or more feet above the ground; or a light beam nailed to trees or other firm supports at both ends. Two pulleys, large enough to take a sash cord, are screwed into the beam a couple of feet apart.

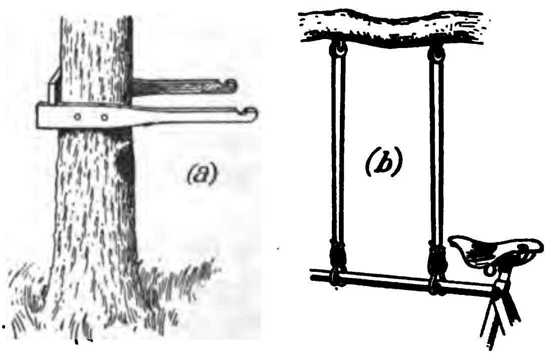

Fig. 150.—(*a*) Cycle suspender; (*b*) sling.

The hoisting ropes have a hook at one end to lift the machine, and a second hook at an intermediate point on the other side of the pulley for securing the rope to the cycle when lifted. If the pulleys be out of reach, the hook ends of the ropes should be weighted sufficiently to bring them down when the other part of the rope is lifted.

This kind of sling enables a man's or lady's cycle to be cleaned on both sides without turning it round.

A CLIP FOR HOLDING PATCHES.

The simple apparatus shown in Fig. 151 will be found very effective for making solutioned patches stick to the inner tubes of cycle and motor-car tyres, and to the inside of cycle and motor-cycle covers. It is especially useful to hold a patch in place while the tube is inflated in search of other leakage.

The size and strength of a clip will depend upon

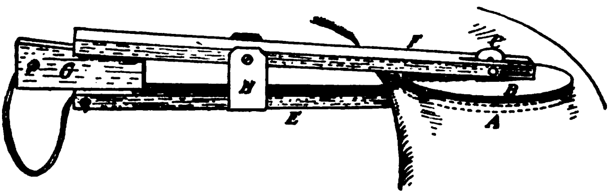

Fig. 151.—A patch clip.

the size of the tubes for which it is intended, but the construction is exactly the same in all cases. The materials required are: a couple of stout iron or (preferably) brass discs of a diameter equal to the width of the flattened tube; a little sheet brass; and some slips of oak.

One of the discs, A, has a hole drilled and countersunk at the centre for a screw. To the back of the other, B, is soldered a little L-shaped brass lug, C, drilled for a pin. Cut two strips of oak, E and F, of the same width, and slit one, F, down the middle

for an inch or so to take the projecting part of B. Drill a hole for the pin D, put B in place in F, and screw A to the end of E. Next prepare the U-shaped pivot-piece, H, and screw it to E.

The wedge G is made of the same kind of wood as E and F. Lay something as thick as a flattened inner tube between A and B, adjust the discs in line with each other, and push the wedge halfway in. The position of the hole through H and F for the pin can then be decided; that in F should be near the upper face.

The taper of the wedge must be sudden enough to prevent the wedge touching E and F anywhere but at the ends when pushed in.

A clip of this sort for motor-car tubes will need to be stoutly made, as the force exerted must be proportionate to the size of the patches.

A CYCLE BOX.

A box to contain all the tools, cloths, and odds and ends needed for cleaning and adjusting a cycle should be as useful to the cyclist as is a housemaid's box to the servant, since it enables things necessary for the work to be kept together and transported to any place with a minimum of trouble. The box illustrated in plan by Fig. 152 is about 12 in. long, 11 in. wide, and 6 in. deep outside. Sides and bottom are of ¾ in., divisions of ⅜-in. wood. The height of the divisions varies, those for brushes,

rags, and gloves being full depth, the rest coming only part way up. The outside is painted, to protect the wood against damp earth or grass. Eighteen inches of thick strap nailed to the middle of the ends outside serves as a handle. To keep out

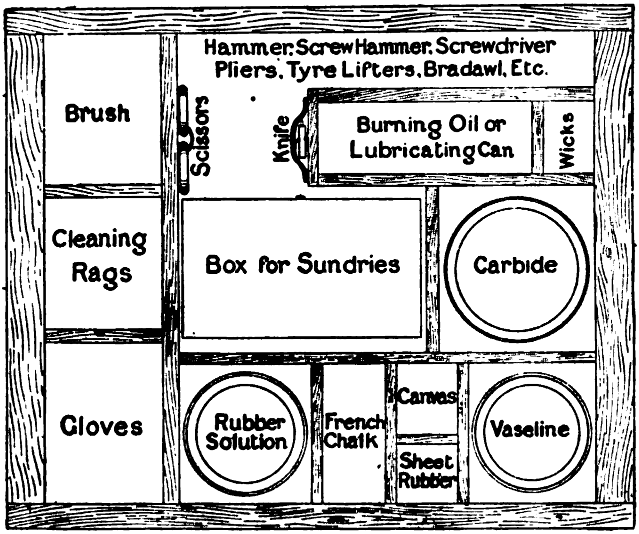

Fig. 152.—Plan of handy box for holding accessories for cleaning, adjusting, and repairing cycles.

dust and dirt the box should be provided with a loose cover of wood, slotted at each end to be held by the strap when in place, or of American cloth nailed to one side, and buttoning over brass-headed nails in the other. Leather loops are provided to hold the scissors, knife, and some of

the tools. The box for sundries—such as spare valves, valve caps, steel balls—is removable. French chalk, patching canvas, sheet rubber, and wicks are stored in tin boxes.

JACKETING A HOT-WATER CISTERN.

A hot-water cistern exposed to the air dissipates its heat quickly. In summer it may make the room in which it is unpleasantly hot; while during winter nights it will cool down so thoroughly that the matutinal hot-water supply will have an unsatisfactory low temperature unless the fire has been lit betimes.

A well-jacketed cistern, on the other hand, keeps hot long after the fire is out; and, owing to smaller wastage of heat, warms up much more quickly than an exposed one. Special boiler felt, about three-quarter inch thick, is an excellent heat conserver. A strip should be obtained with a width and length equal to the height and circumference respectively of the boiler, and a piece as large as the top. If the boiler touch the wall, that side will not require covering; and the bottom, which radiates comparatively little heat, may be left bare in any case.

Assuming that there be sufficient room all round the boiler for the felt, it is fitted round the sides in one piece, and secured by tapes, straps, or hooks and eyes. If the flow and return pipes from the boiler enter at the side, and not at the bottom, the

join should be in line with them, notches being cut in the edges of the felt to fit the pipes. If the boiler stand against the wall, the felt must be tied to eyes screwed into wall plugs, or to wedges driven in lightly between boiler and wall.

The piece for the top is slit to pass over the service pipe, and strapped or tied to the vertical part of the jacket.

A handy carpenter could easily make a neat wooden casing of matchboarding to fit outside the felt and keep in the heat yet more effectively. The parts of the casing should be screwed together so that the manhole may be got at without difficulty. If the wood be fairly stout—say 1 in.—the felt need not be so thick as where it is used alone, wood itself being a good non-conductor. The boards may be held together by battens on the outside, or by $\frac{1}{8}$ in. strip iron on the inside; and each side should have its corresponding part of the felt lining tacked on to it separately.

On the manhole side the jacket stands away an inch or more from the cistern, so the intervening space should be filled up at the top with oddments of felt or other soft material to prevent circulation of air.

Asbestos is an excellent non-conductor of heat, and can be applied very easily to an unpainted boiler or cistern. The surroundings of the boiler having been protected from splashing, and the

temperature of the water raised to about 150°, a quantity of asbestos powder is mixed with water to form a stiff paste. Small pellets of this are flung on to the metal with a trowel, and smoothed down to form a coating half an inch thick. When the asbestos has dried through—as will be proved by its turning a lighter colour—a second coat is added in the same way, and, if necessary, a third. The dry asbestos can be distempered or painted, preferably with aluminium paint.

It is advisable not to cover the manhole lid, as the breaking through of the asbestos to reach it would probably start peeling.

A TRIMMING KNIFE.

Out of $\frac{3}{8}$-in. oak cut a piece to the shape shown in the sketch (Fig. 153, *a*), 9 in. long and 1 in. wide at the handle end, but tapering from $\frac{1}{2}$ in. to $\frac{5}{16}$ in. for the rest of its length. The small end is slit for about three inches with a fine saw, rather nearer one side than the other; and two holes, as far apart as the centres in the two holes in a Gillette razor blade, are drilled to take small brass screws. The holes in the thinner end slip should afterwards be carefully enlarged to the full size of the threadless part of the screws. Trim off all corners and rub the wood down with sandpaper. The blade is inserted in the slit and secured by the screws.

A smarter article is made by cutting off two 8-in.

lengths of $\frac{3}{8}$-in. by $\frac{1}{16}$-in. brass strip and drilling and tapping them both, at what will be the blade end, for $\frac{1}{8}$-in. screws. The two are then tinned with solder on one side—except for three inches at the blade end—screwed together, and heated to make

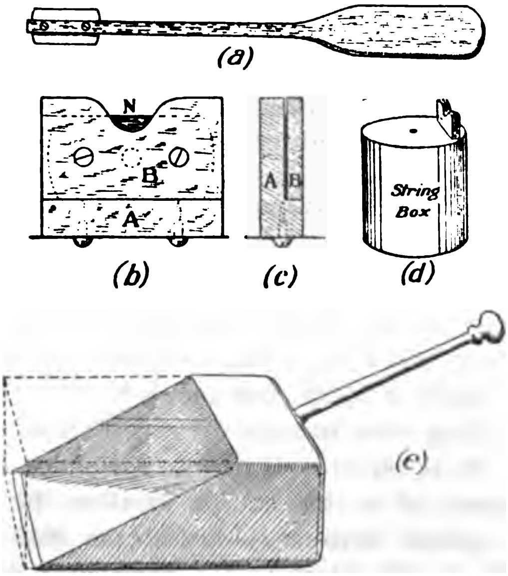

Fig. 153.—(*a*) Print-trimmer made from safety-razor blade; (*b*, *c*, *d*) string cutter; (*e*) scoop made from tin box and hat-peg.

the solder run. The bar, as it now is, has its rear end filed to a sharp point for driving into a wooden handle, or has a handle formed on it by binding with string or some other material.

These razor blades are ideal for trimming photo-

graphic prints, and cards up to ⅛ in. thick. They cut more cleanly than the sharpest knife, owing to their thinness; and as there are four corners, one blade will last a considerable time. When all the corners have been blunted, they may be easily sharpened up on a fine-grained hone, if the supply of blades become exhausted.

A cardboard or leather sheath should be made to cover the blade when the cutter is not in use, as it would do serious damage to a hand laid carelessly on it.

A STRING CUTTER.

In Fig. 153, *b* and *c* are front and side views of a string cutter for screwing to the top of a string box (Fig. 153, *d*). A piece of hard wood ⅝ in. thick, 2 in. long, and 1½ in. wide is slit down the middle to the depth of 1⅛ in., and a cross is made parallel to the long sides to separate part B from A. A notch, N, is cut in each part to the shape shown, chamfered off on the outside to allow the twine to be pulled downwards against the blade, and smoothed with glasspaper. The blade is laid against the inner face of A, and B is screwed up against it. The cutter block is then attached to the string box by screws put in through the lid. The wooden projections on each side of the notch render the danger of cutting fingers on the blade very small.

A SCOOP FROM A TIN CANISTER.

Mark a canister of rectangular section—such as cocoa is generally sold in—as shown in Fig. 153, *e*, and cut along the lines. The remaining original edge is bent over for one-eighth of an inch and hammered flat to give extra strength where there will be most wear. All rough edges and points left by the cutter should be carefully filed off. For handle one may use a penny metal hat-peg attached by screws passed through it and the tin into a thin block of wood inside, or a file handle or other piece of round wood may be bevelled off slightly and secured by a screw put through into it from the inside.

PLANT COVERS FROM OLD PHOTOGRAPHIC PLATES.

Old negatives or spoiled plates of half-plate or larger size can be utilized for making glass covers for seedlings and objects which need protection from dust, such as clocks, and for small aquaria. The plates must be deprived of their films by washing in boiling water, and should be rubbed quite clean.

If the making of a considerable number of covers, etc., be projected, it will be worth while to prepare templates of cardboard round which to arrange the plates while they are stuck together. One is needed for the bottom and another for the top.

Having ascertained the exact shape of the space

enclosed by the plates when assembled, cut out two pieces of stout card to the precise dimensions, trim off the extreme angles, and stick them to other larger pieces.

The contiguous edges of the plates are smeared with some waterproof cement, such as caementium, and brought into contact round the template. The upper template is then laid in the top end and weighted, and the plates are bound round with string, which is not removed till the cement has set. Then remove the top template and cement on the cover glass, previously cut to the right length.

To make the joints more secure, they may be bound outside with strips of linen smeared with the cement, and flooded inside with negative varnish.

Triangular seedling covers might have the top loose, so that it may be propped up to admit air.

PAPERWEIGHTS FROM PHOTOGRAPHIC PLATES.

Useless negatives and spoiled dry plates can be put to a useful purpose as paperweights. A dozen quarter-plates weigh about 1 lb.; as many half-plates, 2¼ lbs.

The plates (with films on) should be soaked in warm (not hot) water for a short time, blotted on both sides, and allowed to dry until the surface is tacky. As many as it is intended to group

together are piled up, film against plain glass side, in an angle of a square-cornered box, adjusted as correctly as possible, and weighted. They must be left thus until the gelatine films have stuck them firmly together. Two or more groups can be treated in one pile if care be taken to have a plain glass side outermost in all groups.

The sharp edges of the groups should be rubbed down with emery powder and water or on a wet hearthstone or doorstep.

The weight is then neatly covered with very tough paper, stuck on with seccotine, or with linen, baize, or other suitable material stitched at the back. A ring or loop should be provided for lifting. If perfect flatness of the under side be not important, the group of plates may be merely tied together with tape.

A couple of dozen quarter-plates make a very useful weight for sticking down the flaps of envelopes.

HOME-MADE FILES.

The handy man is sometimes in a difficulty because he only possesses a few files, whereas the various odd jobs which come his way really need a good assortment.

This difficulty can be largely overcome at the cost of a few pence. Buy a few sheets of emery cloth of various degrees of fineness. Then plane up some pieces of wood. Use the best, hardest,

and straightest-grained wood that you have, for only small pieces are needed, and they will last a long time.

Make some of them square and with parallel edges; some with one edge rounded; and others wedge-shaped in cross section. Then carefully glue some emery cloth on to them. Put the glue on thinly but evenly, and place the "files" under pressure while they dry.

Gluing the cloth to a hard surface greatly adds to its wearing powers, so that these files will last for quite a long time, and do a lot of work before they need to be recovered.

Similar tools are useful for woodwork, but for these glasspaper should be used.

CHEAP DEVELOPING DISHES.

Get some empty fig boxes, clean them well, inside and out, and draw any nail stumps in the top edges. Drive *fine* wire nails in half an inch apart round the bottom, and a quarter of an inch apart up the sides, to bring the wood into close contact at all points. If the bottom be in two parts, caulk the crack with unravelled string forced tightly into place. Enlarge the crack if it be too small to admit the yarn.

Now place half a pound of paraffin wax in a pan large enough to take the box flat, and stand it over a spirit-lamp till the wax fumes. Pour off

the wax into a warmed vessel, set the box in the pan, and empty the wax into the box. When it has stood a minute or so, pour the wax into the pan, reheat, and stand the box in it, first bottom downwards, and then on all the sides in order, tilting the pan about so that there shall be no "high-water marks." If the wax be allowed to soak in well, the wood will be quite waterproof; but it is essential that the box should be quite dry before waxing commences. The lifting of plates will be made easier if two very thin slips of wood be attached to the bottom by pins, cut off short.

WHIPPING A ROPE END, ETC.

Take a piece of waxed thread long enough to go round the rope a couple of dozen times.

1. Bend one end into a loop, and lay the loop on the rope, as shown in Fig. 154, *a*.

2. Give the thread a few turns round the rope over the loop, part of which projects (Fig. 154, *b*).

3. Draw the short end, B, through until the loop is hidden under the whipping, and cut off the surplus close to the last turn (Fig. 154, *c*).

4. Lay the free end, A, on the rope, and continue the whipping over it with the slack (Fig. 154, *d*).

5. Finish by pulling A under the whipping until all slack is taken up, and cut off close at the point where it comes out. The finished end will appear as in Fig. 154, *e*.

Exactly the same procedure is followed in binding the end of a stick. In the case of a very long whipping, as on the handle of a cricket bat, the finishing off is done differently. When the binding is almost complete, a small loop of very fine string

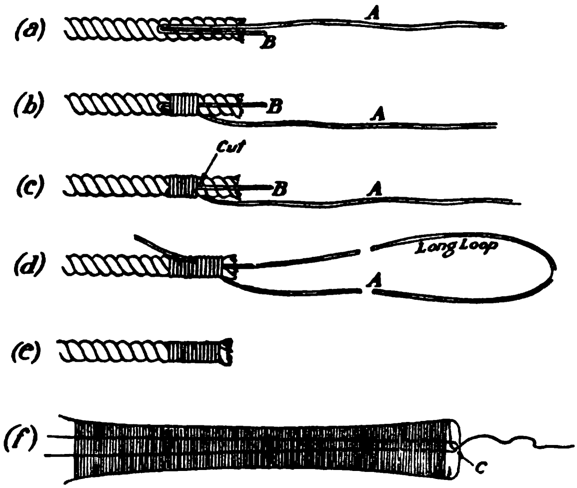

Fig. 154.—(*a–e*) Whipping a rope end, (*f*) and cricket-bat handle.

is laid on so that it projects a little beyond where the last turn of the finished binding will be. When the binding string has been cut off, tuck the end through the loop and draw it under the binding and out by means of the loop, and cut off close (Fig. 154, *f*).

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Note—Figures in *italics* refer to illustrations.

THE END.

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